Biomass Procurement at Middlebury College: Assessments and Recommendations

Environmental Studies Senior Seminar
Middlebury College
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Executive Summary

In January 2009, Middlebury College opened a $12 million biomass gasification facility, annually offsetting 1 million gallons of #6 fuel oil with 20,080 tons of woodchips and reducing carbon emissions by an estimated 12,500 metric tons per year. As of December, 2009, the plant has successfully and reliably provided the College with heat from woodchips through a broker, Cousineau Forest Products. Currently, there is no information available about the source or harvesting practices used to procure the College's biomass, which makes Middlebury unable to confirm whether the chips are harvested in an environmentally sustainable and socially responsible manner and prohibits us from substantiating the claim that the biomass facility is a carbon neutral operation. The following report, based on in-depth research and interviews with the many stakeholders affected by the College's biomass procurement, details proposed biomass harvesting standards, monitoring strategies, challenges to achieving our standards, and alternative supply options.

Standards for biomass procurement are essential to ensuring the College's commitment to sustainability is realized in the production of heat. Unfortunately, existing standards are insufficient. An evaluation of existing forestry standards, including those of Vermont Family Forests (VFF), Forest Stewardship Council (FSC), the Sustainable Forestry Initiative (SFI), and Burlington Electric Company, reveals that none suit Middlebury's biomass needs in terms of scale of operation, availability within a 75-mile radius, and need for biomass instead of high-quality wood. The Fall 2009 Environmental Studies Senior Seminar (ES 401) integrated these standards, keeping in mind the College's specific situation and scale, and proposed standards for procurement that encompass sustainable forestry, wildlife habitat protection, water quality, and aesthetics and recreational considerations. This report provides details of these standards, including, for example, a ban on whole-tree chips, protection of endangered Indiana bat habitat, Vermont Water Quality Accepted Management Practices, and site safety.

These standards would be meaningless without corresponding implementation and monitoring strategies. While many monitoring possibilities are discussed, we recommend a hybrid option with a part time professional forester visiting logging sites in the field using a rubric for monitoring standards (see appendix), and a student position in charge of administrative roles. Following a two-year period to assess baseline practices, there would be a ten year gradual ramp up of standards with the goal of every source site meeting or exceeding 85% compliance. Carbon cycling and accounting, a crucial aspect of the College's goals, is missing due to the lack of scientifically proven information. If the College claims the plant is carbon neutral, there must be a way to account for the carbon and ensuring that the carbon emissions resulting from the procurement and burning of biomass can be sequestered into forests within the same radius.

There exist numerous challenges the College must consider when sourcing and monitoring biomass in a way that meets its environmental, social, and economic goals. The report assesses these challenges as they relate to four main topics: managing the supply; maintaining the reliability of supply; meeting the College's financial needs; and community relations. For example, the supply reliability assessment involves a consideration of the ecological capacity of surrounding forests; the implications of

restricting biomass supply within a certain radius of the College; potential ways to diversify supply; and local and international market forces that may affect a reliable supply in the future. Understanding that adding standards may impact the cost of biomass chips, we assess the maximum price the College could pay for biomass by targeting certain internal rates of return on the initial investment in the biomass plant at different prices of oil. Given that the switch from oil to biomass has generated significant savings for the College, we propose that the College could afford a more expensive, but more sustainable biomass chip.

The report also outlines alternative sources to current biomass supplies, which would potentially decrease the College's impact on surrounding forests, stimulate the local economy by introducing new commodities, diversify our current sourcing options, and provide significant educational and community opportunities. A detailed economic and environmental analysis of the potential for growing willows for biomass suggests that they could provide many benefits in terms of cost, carbon cycling, and direct control over sourcing. Nonetheless, there are also numerous uncertainties including chip moisture content, harvesting and storage possibilities, land options, and the social impacts of converting cropland into fuel sources, and therefore the College should proceed at a pace that allows for trial and error. Additional possible sources of wood chips detailed in the report include stump dumps, mill residue, and an aggregation site in Ripton for local, small landowners. Alternative management scenarios could include a hybrid of a broker for part of the supply, with the remaining portion coming from an aggregation site, direct sourcing from willows and stump dumps, and an outside partnerships such as the Middlebury Energy Biomass Cooperative,. An additional important step in solving our fuel needs and reducing our carbon impact is to reduce our heating and energy demands on campus, and numerous strategies with significant impact and small investment are outlined in the report.

In conclusion, the ES 401 class proposes the following recommendations:

1) Identify where the College's biomass is coming from and how it is harvested.
2) Adopt and monitor proposed ES 401 standards.
3) Develop better carbon accounting and carbon transparency.
4) Experiment with potential alternatives to the current supply.
5) Continue efforts to reduce energy demand on campus.

I. Introduction

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In light of the seriousness of global climate change, Middlebury College pledged to reduce its carbon footprint and aims to be carbon neutral by 2016. The carbon neutral initiative has put the College at the forefront of institutions taking action on climate change. In February 2009, Middlebury College opened a $12 million biomass gasification system that uses woodchips to provide about half of the College's heating needs. The plant is a major element of Middlebury's carbon neutrality initiative. This shift towards sustainable fuels replaces approximately 1 million gallons of #6 fuel oil each year. Utilizing local, renewable energy sources is a socially, economically, and environmentally responsible choice for a large institution. Since its activation, the plant management has worked out the intricacies relating to how to operate the biomass plant reliably and efficiently. With a functioning biomass facility it is essential to assure the sustainable procurement of wood chips. The College's current contract with Cousineau Forest Products provides 20,000 tons of woodchips annually, but the contract does not yet include biomass procurement standards. The College now hopes to develop and implement specific recommendations regarding how we procure fuel. It is important to assure the production of fuels is truly consistent to the College's sustainability goals.

Goals

The goals of this Environmental Studies Senior Seminar project are to:

1) identify current biomass sourcing practices;
2) develop sourcing standards to ensure that biomass is a sustainable energy source for the College;
3) create a monitoring scheme to enforce those standards;
4) outline a more robust set of carbon accounting tools for the College.

Importance of Ethical Biomass Sourcing

In the development of an improved procurement policy, Middlebury College must be mindful of existing commitments and larger implications of the changes. Specifically, Middlebury must consider:

Biomass is not necessarily sustainable, but Middlebury is already committed to biomass.

There have been many debates about the merits of using biomass as a heating and energy source. Middlebury has already committed to biomass by building its plant, so the College should focus on how to best go about sourcing biomass. Standards can ensure that Middlebury's biomass procurement is both economically and environmentally sustainable.

Middlebury's choices are influential.

As an educational institution, Middlebury's actions provide a model to other institutions, groups, and individuals who are pursing biomass as a heating source, or are thinking about entering the market. Others are looking for guidance on how to properly

procure biomass, and Middlebury should strive to establish standards that can hold up as the biomass market expands.

Middlebury is committed to environmental initiatives.

Middlebury has built a reputation of strong environmental initiatives and needs biomass procurement standards that help demonstrate the College's commitment to sustainability.

Value of collecting different viewpoints.

It is important to consider the opinions of the various interests in the biomass market. Landowners, loggers, contractors, biomass users, and stewards of Vermont and New York's forests may provide valuable insight in the future of our fuel sourcing.

Key Considerations to Sustainable Sourcing

There are many considerations in the development of a successful sourcing policy. The way in which we structure our procurement has bearing on the College, the community, and larger biomass markets.

Any policy must first and foremost assure a reliable supply of chips. Any endangerment to our supply puts an unreasonable amount of pressure on our oil burning facility. The current system has assured constant steam that drives the College's heating and cooling systems throughout the year. Any proposed system that has the possibility of impacting reliability will be summarily rejected by the College. The necessity of this concern assures that new standards will include significant flexibility. It is important to work with Cousineau and other interests while developing standards to assess the most problematic features of our proposition.

Beyond ensuring a constant supply, any sourcing plan must work towards the College's goals for sustainability. This, after all, was a major justification for the creation of the biomass plant. A reconsideration of sourcing must not only improve the environmental sustainability of our heat system but also assure economic viability and social sustainability. It is important to realize the inherent improvement of the biomass plant. The substitution of biomass for 1,000,000 gallons of #6 fuel oil is a significant step towards sustainable behavior. However, it is also important to assure sustainability of the entire fueling cycle if our claims are to be credible.

Improvement in environmental sustainability is the most obvious achievement of Middlebury's biomass facility. Since its inception, the plant has been touted for its major contribution to Middlebury's sustainability ethic. This is easy to justify. It is the College's intent that over half of its fossil fuel use be replaced by a renewable source of energy. Therefore, our efforts to develop sourcing standards must assure that the shift not produce auxiliary effects in the form of unsustainable harvesting. Considerations within the umbrella of environmental sustainability include the assurance that these resources will, in fact, regenerate. Our proposed standards will address rates of regeneration as well as other concerns such as site productivity, water quality, biological diversity, carbon sequestration capacity, forest vitality, and wildlife habitat conservation.

In addition to these tangible goals, the sourcing ostensibly helps to achieve the College's goal of carbon neutrality. Middlebury publicizes carbon dioxide emission reductions from the plant at 12,500 tons annually. This is calculated by assessing the carbon dioxide in fuel oil that has been replaced by biomass. While the combustion of wood chips produces significant amounts of carbon dioxide, the nature of its origin

means that it has been sequestered on a biological timescale instead of the geologic periods needed for fossil fuel creation. However, there are ambiguities in the College's definition of carbon neutrality. New sourcing policies seek to determine the currently uncalculated transportation and harvesting emissions. Also, standards must assure that forest management allows sufficient ability for sequestration and that harvesting does not result in a reduction in forest site productivity or accelerated forest biomass decomposition.

Beyond environmental sustainability, our sourcing plan must facilitate economic viability and social sustainability. The economic component is most easily incorporated. Any component of the plant's operation or sourcing that is not sensible from an economic standpoint is understandably met with great resistance from the College and chip suppliers. Construction of the plant assumed a return on the College's investment in 11 years. Any significant extension of this period will be largely unacceptable. While complete economic commitment to the procurement of sustainable chips is not feasible in light of current economic conditions, it is hoped that economic recovery will generate funds to support the procurement of sustainably harvested biomass.

Further considerations include the fragile local biomass markets. Middlebury plays an admittedly small role in the biomass markets of Vermont and New York. Larger entities like Burlington Electric burn fifteen times as much biomass as Middlebury. However, on a smaller scale Middlebury does affect local supply. Many local public high schools are also dependent on local biomass. Consideration for these other users limits, for example, the College's procurement of mill residue during the winter months.

On a larger scale, creating an ecological and ethical sourcing scheme is essential in an important regional market. The last century has seen the reforestation of Vermont and northern New England. With reserves of biomass, the burgeoning industry must expand in a sustainable manner. We can serve diverse interests by creating a procurement system -- including standards, monitoring protocols, and system assessment -- that can be informative for other biomass users. Green Mountain College is soon opening a similar biomass facility. Likewise, Middlebury's influence might help groups in the struggling logging industry find a profitable, ecological niche. Cousineau Forest Products has no other customers expressing a desire to procure chips with specific sustainability standards. It is an opportunity to create infrastructure to facilitate such arrangements.

II. Current Biomass Procurement

Current Wood Fuel Supply

The State of Vermont and the surrounding states of New York, Massachusetts and New Hampshire have abundant forests. Vermont, in particular, is more than 78 percent forested. Due to the relative abundance of forest products, energy from wood has long been used in Vermont. Biomass energy for power has been used for nearly 25 years. Large woodchip consumers include power plants such as Burlington Electric Department, and pulp mills such as the International Paper (IP) Ticonderoga Mill, which respectively burn 380,000 tons and 800,000 tons of woodchips annually. Vermont schools together burn around 18,500 tons of woodchips during the school year.[1]

Defining the amount of annual available biomass that can be sustainably and realistically harvested in Vermont is dependent on a number of assumptions and variables. According to a study by the Biomass Energy Resource Center (BERC) there are approximately 1.0-1.5 million tons of low-grade wood grown each year on timberland that is harvestable in Vermont. However, this number is highly reliant on the estimated forest growth rate.[2] BERC estimates use a growth rate of 2.4 green tons per acre per year. Alternatively, according to the Vermont Department of Forests, Parks, and Recreation the most reliable growth rate of the Vermont forests is 1.25 green tons per acre per year. Therefore, biomass availability is highly uncertain and differs significantly depending on assumptions of growth rate.

Vermont's forests are primarily owned by non-industrial private landowners. The amount of biomass available is therefore greatly reliant on these private landowners' desire to engage in harvesting practices. Private forestland is already used extensively in other forest product sectors (e.g. high-quality timber, firewood, etc.). In Vermont, many forest landowners are in the Use Value Assessment (UVA) program that requires them to practice active forest management on their lands. (UVA is described further in Barriers section). Yet, the rate of forest landownership turnover and changing parcel size can affect the amount of the low-grade biomass harvested on these lands.[3]

Currently the biomass market is dependent on the high-quality wood market such as sawlogs and the large low-grade wood markets such as pulp. Stand-alone chipping for biomass operations have historically not been economically feasible. As the table below depicts, sawlogs and pulp lead to a net gain for the supplier, whereas biomass leads to a net loss for the supplier.

	Per Ton Basis		
	Sawlogs	Pulp	Biomass
Mill Pay (+)	$90	$35	$28
Harvest (-)	$35	$20	$30
Trucking (-)	$12	$12	$12
Chipping (-)	$0	$0	$2
Net	$43	$3	$ -16

Table 1: Profit break down for sawlogs, pulp, and biomass[4]

In the past ten years, pulp mill and paper mill ownership turnover and mill closures in the Northeast have been at an all time high. In Vermont, loggers and mills are surviving—but just barely.[5] Therefore, the cost of biomass is projected to increase as the saw log and pulp industries demand declines. Furthermore, as the price of oil continues to climb, there is also an expected increase in price of biomass because the overall expenditure for the harvest, chipping and shipping of biomass will increase assuming that the machinery used for these tasks use oil for fuel. Also, rising oil prices will increase demand for comparatively cheap biomass.

Product Origin Information

As our contracted biomass supplier, Cousineau Forest Products supplies the College with the required amount of biomass in order to run our facility at all times of the year. Initially, Middlebury College desired a contract with a single supplier of biomass that was within seventy-five miles of the College.[6] When a single supplier could not be secured, the College decided to pursue a contract with a broker. Because the College had no experience in the procurement of biomass, it was important to work with a company with a proven track record in biomass procurement. Cousineau Forest Products was found during a search of biomass brokers in Vermont, New England, or Canada. The companies were screened for reputation, track record, proximity, price, and experience with customers the size of Middlebury College. Cousineau demonstrated the best combination of those factors. Middlebury College's contract with Cousineau Forest Products is limited to three years, starting in January 2009. In the contract, the College and Cousineau agreed to work with suppliers to move substantively in the direction of following sustainable forestry principles over the next few years, but little progress has been made towards these goals.

The supply chain from forest to biomass facility is never of a set length, rather Cousineau uses a variety of suppliers and sources to procure the necessary biomass for the College. Information about this supply chain is currently almost entirely absent from the College's records of its biomass procurement. In order to make increasingly informed decisions about the sourcing of the College's biomass, as well as to convincingly label the facility as "carbon neutral," it is necessary to begin the collection of information regarding the source of the biomass, including: site location, size of cut, date of cut, and type of cut. In many instances the College receives biomass that has been chipped on site, which would allow for this information to be easily gathered and recorded. In other instances, depending on time of year or availability of alternatives (mill residue, etc.), biomass often travels through multiple intermediaries which makes this information significantly more difficult to acquire. In such instances the information should be pursued to the maximum possible extent allowed by cost. This information is essential in assessing the overall role the biomass facility plays in the College's carbon neutrality commitment, as well as being fundamental in order to make increasingly informed decisions about sustainable biomass sourcing in the future.

III. Creating Biomass Sourcing Standards

Evaluation of Current Forestry Sustainability Standards

From the outset, it was apparent that a set of standards is necessary in order to ensure that biomass purchased by Middlebury met the goals that the College set in the early stages of planning for the biomass facility. These goals, as mentioned above, were established with the express purpose of promoting forestry (via our purchases of biomass) that produces positive ecological, economic, and social outcomes. To this end, we examined existing standards that have been created by organizations that purport to have similar goals as those laid out by Middlebury College. Our objective was to determine if there was already in existence a set of standards whose adoption would allow the College to move forward in achieving the ultimate goals for our biomass plant.

Research revealed a number of existing sets of standards dealing directly with biomass harvesting and sustainable forestry practices; we decided to look first at those laid out by three well-known organizations specializing in these fields: the Forest Stewardship Council (FSC), the Sustainable Forestry Initiative (SFI), and Vermont Family Forests (VFF). The former two organizations are third party certifiers who confirm that landowners and/or loggers meet their organization's standards. However, these certification standards were found to be problematic on a number of levels as our studies identified issues regarding both content and logistics of SFI and FSC criterion. We then studied the forest management standards of VFF (a Vermont-based non-profit focused on conserving natural woodlands within the state) and Burlington Electric Department (BED), with the hopes that the proximity of these organizations would render their standards more applicable to the situation of Middlebury College. However, as was the case with FSC and SFI, neither VFF nor BED were determined to have standards that fully aligned with the specific goals and situation of the College's biomass facility.

It became clear that in order to fulfill the need for such a set of standards, the College would have to create its own criterion of forest management practices to be employed in the procurement of biomass burned in the Middlebury plant. After extensive study of the aforementioned criteria, we decided that the best course of action was to glean from each of the standards points that fit the bill of being both applicable to Middlebury's situation and aligned with Middlebury's goals for the biomass plant. The result was an amalgamation of standards we feel constitutes a sound first step towards achieving the College's goals regarding biomass energy.

Forest Stewardship Council

The Forest Stewardship Counsel (FSC) is an independent, non-profit, non-governmental organization that was founded in 1993 in response to growing concerns over global deforestation. FSC works to promote responsible management of the world's forests through a certification system that establishes international standards and provides accreditation to companies, landowners and other organizations that are involved in sustainable forestry activities. Rather than boycotting poor forestry practices, however, FSC aims to use market forces to promote forest management that produces social and ecological benefits while remaining economically viable.

To date, FSC certification is present in 50 countries worldwide. However, it is important to note that FSC does not issue certificates itself; instead, FSC relies on certification bodies –all of which undergo a rigorous accreditation process to be able to issue FSC certification– stationed around the world to issue certificates. There are three types of certification available under the auspices of FSC: the forest management certification (FM), the chain of custody certification (CoC), and the controlled wood certification (CW). Forest managers or landowners who want to demonstrate that their forest is managed in socially, environmentally, and economically sound ways apply for the FM certification. In this process, the land in question is checked by an independent third party organization, accredited by FSC, which verifies that management of the forest meets FSC principles and guidelines; certification of a forest does not, however, ensure that wood harvested from said forest is FSC certified wood. For wood to be FSC certified, the forest it is harvested from must have a FM certification while the loggers (and any other workers involved in harvesting) must have a CoC certification. This

certification is mainly for companies that manufacture, process, or trade timber or other forest products and want to demonstrate their fidelity to responsibly procured wood. The CoC traces FSC certified timber as it flows through the chain of production, thereby helping companies strengthen or more closely monitor their sourcing policies.[7] The final type of FSC certification is the CW certification, which enables landowners to supply FSC wood to FSC CoC operations. To be deemed 'FSC wood,' the company responsible for harvesting must enact forest management plans deemed to comply with five controlled wood criteria and the wood must then be sold to CoC certified operations.

Encompassing the three types of FSC certification, there is a set of FSC principles and guidelines that deal with sustainable forestry. In general, FSC criteria are much more concrete than those of other third party organizations we looked at, specifically, SFI criteria. FSC presents more specific, action-based standards that must be met in order for certification to be awarded. There is an emphasis on ecological as well as social sustainability; this focus on the impact that forestry activities have on communities and individuals not directly involved in the process are of paramount importance and must be included in any set of standards adopted if Middlebury wishes to move toward its original goal of sustainable woodchips harvested in a socially and environmentally sound manner.

Some of the most important aspects of FSC for the College to consider in creating our own standards are the need for transparency regarding forestry activities, requirements for written management plans, consistent monitoring of the implementation and effects of management plans, and the social (on both individual and community levels) effects of forestry activities.

We therefore feel that many of the FSC principles should be used to guide the College as we write our own standards. Many of the principles could be adopted directly while others may simply serve as direction for the evolution of new standards. The principles that are summarized below are those that we feel are the most helpful as we create our own standards.

- Require transparency on the part of both loggers and landowners, making information regarding biomass harvesting accessible to the public.
- There are provisions for individuals or groups who do not have direct economic or legal land rights to participate in the management of nearby and/or culturally significant forests.
- Provisions for dealing with land management disputes.
    - The policy of refusal to grant certification (or revocation of previously issued certificates) in cases where land disputes cannot be resolved in a timely manner prevents poorly coordinated and monitored forest management from occurring.
- Assertions that the long-term socio-cultural, economic, and health effects of forestry activities on loggers and nearby communities must be taken into account before going forward on forestry activities.
    - Principles carefully address the issue of safety on logging jobs, an issue that is central to the social responsibility of forestry activities. Additionally, FSC principles assert that communities near forest management areas should be given opportunities for employment, training, and other services; this is also central to the degree of social

responsibility with which logging takes place. Our determination to source our biomass from within a 75-mile radius, thereby aiding local communities via increased job opportunities and cash flow, is an example of the application of this standard for the Middlebury biomass facility.

- Prioritize capital reinvestment in local economies surrounding harvest sites.
- Establish that the rate of harvest cannot exceed the rate of forest regrowth; this represents the rate that can be harvested sustainably.
    - On this and all other issues related to sustainable forestry, FSC principles differentiate between large and small-scale operations. There are corollaries stating that monitoring must be done continually to verify acceptable harvest rates with changes in the forest composition.
- Require that environmental impact assessments be conducted.
- Propose the notion of representative areas against which actively harvested sites can be compared, allowing for more accuracy in monitoring.
    - This is useful for Middlebury due to the ease with which such representative sites could be established on our own forestland. Additionally, this could be useful in terms of monitoring carbon sequestration capabilities of VT forests.
- Call for annual monitoring to assess the success of existing guidelines in producing conservation outcomes.

Despite these positive aspects of FSC certification standards, there were multiple reasons that adopting these criteria was deemed unfeasible. The first and most important is that there is very little land with FSC FM certification and similarly low numbers of FSC CoC certified companies within the 75 mile radius that the College established as the area from within which we aim to procure all of our biomass. Thus, adopting FSC standards would drastically limit possible sources for biomass, threatening reliability of supply, which must remain our foremost consideration as any disruption to supply at this point could have dire consequences for the members of the College community during the winter months. At present, Middlebury does not constitute a large enough market force to successfully incentivize loggers and landowners to adopt costly standards that are irrelevant to most other buyers; thus the current, very limited supply of FSC certified biomass in the surrounding areas would not be likely to increase.

Another important consideration is the pertinence of FSC standards. FSC is an international organization concerned with global deforestation; it follows that its standards for sound forest management practices may differ from those that constitute good forest management in Middlebury, Vermont, where we are concerned with biomass procurement. In fact, there are many FSC criteria that are not relevant for the College's biomass concerns or the circumstances of logging in New England. Adopting these unrelated criteria would make chips prohibitively expensive for the College due to the drastic changes that implementation would necessitate. Some examples of such measures include the FSC call for the full responsibility of landowners –who must ensure that no illegal logging activity takes place on their land, monitor loggers hired to harvest, and assume responsibility for any environmental damage that occurs as a result of forestry activity taking place on their land, regardless of the perpetrators of the pollution– or the assertion that forest owners and/or managers of landholdings greater than 1000 acres

must participate in local economic development and/or civic activities. These requirements would be unreasonable to expect in Middlebury's contextual setting and therefore do not make sense to adopt.

Additional issues considered in determining whether or not adopting FSC standards was a wise or viable decision were the uniqueness of Middlebury's situation and goals as well as the advisability of trusting third party certifications. We were continually confronted with the fact that Middlebury's situation in terms of our status in our small, limited woodchip market is unique, as are the goals we set for ourselves in this specific context, and so it is unreasonable to expect a set of pre-existing standards to fulfill all of our needs. Finally, there is the issue of confidence in third party organizations to sufficiently monitor all standards. If we rely on a third party, any shortcomings on their end in terms of monitoring and enforcement will be reflected on the College and could severely undermine the vast progress that our biomass plant represents. For these reasons, as well as those listed above, we chose not to adopt FSC certification standards in their entirety, but instead chose to select those criteria that we felt worked towards achieving the goals we initially established.

Sustainable Forest Initiative

The Sustainable Forest Initiative (SFI) is a series of sustainability standards developed by The American Forest and Paper Association (AF&AP), a trade association comprised of forest, pulp, and wood products industries. The system is limited to North America where it currently applies to 135 million acres.[8] In Vermont SFI applies to 5000 acres, roughly .1% of Vermont's forested area.[9] While this is the most widely used certification system in the United States there are major flaws. Much of the criticism of the system arises from the fact that it is an industry standard concerned with achievability instead of sustainability.

There are several types of certification schemes under the SFI. The most widely used is the Forest Management Standard. Any agency that owns or manages forestland is eligible to apply for certification. This includes companies, universities, conservation agencies, and timer investment management groups.[10] Independent bodies must certify forestland. Those undertaking the verification must be accredited by the Registrar Accreditation Board or the American National Standards Institute, affiliates of the International Standards Organization. Levels of compliance are assessed and compiled by the AF&AP.[11] In addition to the Forest Management Standard, SFI has a chain-of-custody certification. Any company that trades SFI products may be given this credential. It allows the labeling of products with a indication of what percentage (usually pertaining to fiber) of the product came from SFI land.

Land directly controlled by SFI participants is directly monitored. However, many SFI certified *entities* take wood from a combination of certified and non-certified sources. Seventy percent of SFI wood coming from non-certified SFI landowners (e.g., private owners) is less clearly assured. There is no verification of the origin beyond some random sampling.[12]

Critics of the SFI standards are organized and passionate in their denouncement of SFI. The Alliance for Credible Forest Certification is a group of organizations including the American Lands Alliance, Forest Ethics, Greenpeace, National Wildlife Federation, and the Sierra Club. This group has sought to inform consumers about the issues with SFI

and has encouraged participation in the Forest Stewardship Council's rival system. According to the Alliance, specific ecologically damaging practices allowed under SFI include:

- Widespread logging of irreplaceable old growth forests, roadless areas, and other endangered forests.
- Reduction of natural forests to industrial tree plantations lacking biological diversity.
- Logging, road construction, and other operations that harm water quality, including in states that lack adequate "best management practices."
- Destruction of natural forests for replacement by ecologically degraded industrial tree plantations.
- Permanent conversion of forests to sprawl and other non-forest land uses.
- Excessive, routine use of toxic chemicals across entire landscapes.
- Excessive clear cutting, with entire landscapes allowed to be logged in very short periods of time
- Use of genetically modified trees.[13]

The Alliance also seeks to identify specific SFI certified companies with destructive management practices. For instance, the Weyerhaeuser Company, a SFI credited entity, is accused of clear cutting habitat for threatened Coho salmon, cutting endangered caribou habitat, intensive chemical applications, and genetic modification of trees. Similar dalliances are reported by Plum Creek Timber, Sierra Pacific Industry, and Pacific Lumber Co.[14]

Along with loopholes that facilitate ecological destruction, critics cite inadequacies in the protection of worker and community rights, verification of company's compliance with current regulations, and consultation with stakeholders during assessments.[15] SFI *does* include a voluntary chain of custody certification that allows companies to gather information on their sourcing. This is of great interest to Middlebury as we have identified the procurement information as a priority. However, there are concerns even relating to this specific part of the standard. Not all SFI companies are required to receive the chain-of-custody substandard. Also, most importantly the origins identified by the chain-of-custody are almost never geographic and instead only reveal if the wood is coming from SFI certified forests, assurance it is being attained legally, etc.[16] This is not a sufficient level of specificity for Middlebury.

While many invested interests have expressed preferences for FSC, it is important to observe the different objectives for the two systems. The SFI is an attempt to generally improve the sustainability of the forest products industry throughout the supply chain. In contrast, FSC simply seeks to assign market incentives for well-managed land.[17]

Originally, we considered SFI as a baseline for the creation of our standards. Upon exploring the system further, discovering the national condemnation, and speaking with immediately involved interests, we have decided to create a baseline more stringent than SFI. Other organizations have adopted the SFI standards as a baseline. Most significantly, the United States Green Building Council's Leadership in Energy and Environmental Design (LEED) accepted SFI wood as an acceptable building material for every level of certification.[18] This determination was made after significant lobbying by

AF&PA. While any third party system is better than no standards, the objectives of SFI are not thorough enough for our sustainability goals.

Vermont Family Forests

Vermont Family Forests (VFF) is a community based not-for-profit organization of landowners based in Bristol, Vermont dedicated to the conservation of forest health and, when appropriate, careful cultivation and forest resource extraction. VFF is committed to the maintenance of natural woodlands as healthy, productive and aesthetically pleasing community resources. VFF has created a set of guidelines for forestry management practices that aim to conserve the ecological and aesthetic health of the targeted forest, outlined in its "Forest Management Checklist." These guidelines are tailored to the forests of the northeast.[19]

VFF's checklist is divided into three different stages of the resource extraction process ("Accessing the Family Forest," "Vegetation and Management in the Family Forest," and "Sensitive and Special Habitat Areas"), each with its own subset of recommendations. As the management checklist states, "Owners of lands in the VFF certified pool agree to comply with the VFF Forest Management checklist to the maximum practical extent."[20]

The VFF recommendations offer a number of potentially beneficial standards for Middlebury's sourcing. These recommendations are based on northeast forests as the ecosystem, which makes them very applicable to our situation. VFF also considers the health of the forest as a complete ecological system rather than a machine of productivity, and thus more consideration is given to other aspects of forest health often overlooked when creating logging standards. As VFF has structured these guidelines, there are no *essential* standards, rather it is encouraged that participants follow these guidelines to the best of their ability. As VFF Executive Director David Brynn stated, "VFF recognizes that 100% compliance though desirable is not always achievable. VFF works to identify shortcomings and to improve the quality of management and harvesting."[21] This approach would allow Middlebury to offer some flexibility to potential biomass providers, as well as encourage and facilitate a progression toward higher compliance with an increasing number of these standards.

VFF's recommendations are also largely dependent on Vermont Acceptable Management Practices for Water Quality (AMP's), a state developed set of guidelines. There are some guidelines where there is no measurable standard, which could potentially lead to an increased amount of individual interpretation and confusion on the part of the landowner or logger. Vermont Family Forests' standards are focused on saw timber rather than biomass, so many of their requirements do not apply to Middlebury's procurement of woodchips.

Burlington Electric Department

Burlington Electric Department implemented its procurement standards 1983 when the McNeil Power Station was permitted by the Vermont Public Service Board.[22] BED created the standards following public concern on the negative impacts of biomass harvesting. Burlington Electric Department's standards include regulations on water quality, visual quality, wildlife and fisheries, archeological sites, sustainable harvesting

defined primarily through silvicultural guides, and applicability of local, state and federal regulations.

Each harvest plan must be reviewed by the Vermont Fish and Wildlife Department biologists to ensure adequate practices concerning the conservation of wildlife habitat. Because of this requirement, there is a significant time lag between site selection and harvesting. Currently, BED is working with the Public Service Board to bypass the approval of Vermont Fish and Wildlife Department (VFWD) for harvests that are third-party certified and do no impact critical wildlife habitat. Competing biomass users (schools, state buildings and out-of-state consumers) are not subjected to the same or similar standards which creates a competitive disadvantage for BED. Their foresters monitor the harvest for contractual compliance, including compliance with the harvest plan and applicable regulations. BED does not offer any incentive aside from the risk of losing one's contract with BED for failure to comply with the standards, harvest plans and/or contract. BED has four foresters that weekly monitor each logging site, one forester for each 100,000 tons of woodchips.[23] At any given time, depending on the demand, the foresters visit twenty sites on average per week.

Proposed Standards

In light of the insufficiencies of existing systems we have developed a set of standards to assure future procurement of biomass is accomplished sustainably.

Sustainable forestry:

> "Forests are complex ecological systems. To sustainably utilize biomass from forest ecosystems it is necessary to consider not only trees, but also the soil they grow in, nutrients required for plant growth and the way they cycle, and other biota in the forest. The procurement standards we present are aimed at promoting "excellent forestry" that allows for utilization of wood <u>and</u> for persistence of site productivity and biodiversity. Silviculture is the science of growing trees, and it is widely recognized that in order to practice excellent silviculture it is more important to think about what is left in the forest than what is removed. Seasonality of harvest and size of harvest area also affect the forest ecosystem and the extent of disturbance to it in the course of logging operations. It is, of course, important to consider how biomass is removed, with respect to both machinery employed and access roads for the machinery and people that harvest and transport the wood."[24]

1. Forest management goals will be developed with a professional forester while using recognized silvicultural guides.

   a. **Due to variability in forest stands due to physical site conditions and past harvests, cutting and silvicultural techniques will vary.[25]**

b. **In developing silvicultural techniques for meeting management goals, a combination of the forester's professional judgment and the recognized silvicultural guides, including but not limited to:**
   i. A Silvicultural Guide for Northern Hardwood Types in the Northeast by Leak, Solomon and DeBald
   ii. A Silvicultural Guide to White Pine in the Northeast by Lancaster and Leak
   iii. A Silvicultural Guide for Spruce-Fir in the Northeast by Frank and Bjorkman
   iv. A Silvicultural Guide for Developing a Sugarbush by Lancaster, Walters, Laing and Foulds
   v. Uneven-Aged Management of Northern Hardwoods in New England by Leak and Filip
   vi. A Landowner's Guide to Wildlife Habitat Management for Vermont Woodlands by Vermont Fish and game Department
   vii. Manager's Handbook for Red Pine in North Central States by North Central Forest Experiment Station, U.S.D.A. Forest Service
   viii. A Guide to Hardwood Timber Stand Improvement by U.S.D.A. Forest Service, Northeastern Area State and Private Forestry
   ix. Establishing Even-Age Northern Hardwood Regeneration by the Shelterwood Method- A Preliminary Guide by North Central Forest Experiment Station, U.S.D.A. Forest Service[26]

c. **Sustainable harvesting must consider biodiversity as forest management and utilization have impacts on population of all forest organisms. Different silvicultural techniques have varied effects on biodiversity.**[27]

2. **Average annual removal of woody biomass from the site should not exceed 70% of the average annual growth.**

3. **Biological legacies of the forest community should be protected to retain forest productivity and health.**

   a. **No whole tree harvesting**

      Whole tree chipping damages forest ecosystems by depriving soils of important nutrients deriving from residual branches and tops. These features also serve to provide habitat to a variety of wildlife. Tree tops, branches, and leaves and all material less than 4 inches in diameter should be left at the logging site as soil nutrients for forest regeneration.

      It is understood that it is not reasonable to expect perfect compliance. Cousineau estimates that eliminating whole tree chips would raise our costs ten dollars per ton, or $200,000 per year. This premium is a result of conflicts with firewood and hardwood pulp markets.

   b. **Retain at least 2 down trees or logs per acre exceeding 14 inches in diameter on average.**

Wood-chip harvests often consist of clear-cutting or whole tree harvesting, including the removal of branches and leaves. These types of harvesting often result in decreased levels of nutrients, including losses of calcium, nitrogen, potassium, magnesium and sulfur.[28] Utilizing forests alters nutrient cycles as nutrients are stored in roots, stems, branches and foliage of plants and in the forest floor litter.[29] Because branches and foliage in particular contain the largest amount of nutrients in trees "…in order to adequately maintain nutrient pools and nutrient cycles it is necessary to leave foliage and branches dispersed in the forest."[30] Different harvest intensities and silvicultural techniques should reflect the ecosystem's susceptibility to nutrient depletions. The ability of a forest to recover from a harvesting event is related to the amount of wood left on-site.[31]

Coarse woody debris left at the site after logging is important to achieve sustainability in managed forest ecosystems. "Dead wood is an extremely important aspect of the forest structure…coarse woody debris serves as seed germination sites, reservoirs of moisture, and habitat for numerous species of fungi, invertebrates, and vertebrates; it also plays important roles in nutrient conservation and cycling."[32] "…A diversity array (with regard to species, sizes, and decay classes) of these biological legacies must be maintained in an effort to provide for the full spectrum of dead wood structures in a forest ecosystem."[33]

4. **Cutting cycles should be between 10 and 15 years minimum.**

   Use uneven-aged management by area regulations whenever possible. Intermediate treatments should generally raise the average diameter of the residual dominant and co-dominant trees of the forest while improving timber quality.

5. **Harvesting will promote the protection of residual trees.**
   a. **Residual stand damage should be confined to 10% or fewer of the dominant or co-dominant trees.**
   b. **Great care should be taken to avoid basal wounds on residual trees as basal wounds are ideal entry sites for decaying fungi and bacteria.[34]**

6. **Avoid clear-cutting. Canopy openings should be less than 0.25 acres and no larger than 1.25 acres.**

   The natural pattern for open patches in northern hardwood and spruce-fir forests of northern New England is one of small, disturbed patches within an area of older forest.[35] Harvesting in large, open patches introduces a patch structure significantly different from the natural pattern in these forests. Small-patch silvicultural techniques best mimic the natural pattern.

Wildlife Habitat Protection

1. **Take steps to preserve Indiana bat habitat in areas conducive to their habitation.**

   Every effort should be made to protect Indiana bat habitat. This is an effort to preserve a species that is being threatened by white-nose syndrome, habitat destruction, and cave disturbances. Additionally, as one of two Vermont species listed as endangered, Indiana Bat habitat conservation is mandated by law. While the bats are rare, enough is known to log responsibly. This is an important contribution to a national effort and prevents the obvious issues raised by illegality. The greatest threat posed by our actions is the destruction of summer roosting and foraging habitat. Female bats bear their young in specific types of trees that are easily avoided. Practices should include:

   - Preserve snags whenever possible. Especially those naturally exposed to consistent sun.
   - Specific care should be taken in the southern Champlain Valley, the confirmed area of habitation.
   - Retain dead trees with a diameter of more than 12 inches located within 200 feet of streams, lakes, ponds, or wetlands.
   - Retain Shagbark Hickory and Black Locust.
   - Avoid entire areas with known roost trees.
   - Avoid road construction within 100 feet of known hibernacula.[36]
   - Log with a forester with knowledge of Indiana Bat Management Practices.[37]

2. **Preserve 100-foot buffers of original vegetation between wetland, stream, pond or lake and active cutting areas. On steep slopes extend this buffer strip to 150 feet.**

   Riparian buffers offer diverse ecological services and are essential elements of responsibly managed land. They serve to filter suspended sediments from runoff, removing nutrients responsible for water eutrophication. However, they also provide specific habitat for large numbers of animals, stabilize banks, and regulate water temperature. The necessary width of the buffer is somewhat relative. Different conditions assure that protection of buffers varies at different locations. A broad average suggests that bank stability is preserved with 50 feet of buffer between water and the site; 100 feet assures better water quality due to sediment filtering; and 150 feet preserves habitat protection. [38] 100 feet seems the most reasonable mark to impose. This width is adequate to remove suspended sediments and nitrogen from the runoff.[39] Beyond this width, numerous small streams on a property could severely limit the productivity of a site. However, an additional site variable is bank steepness, with steep banks necessitating 150-foot buffers.[40]

Water Quality

1. **Erosion and sediment control practices are required as outlined in *Acceptable Management Practices for Maintaining Water Quality on Logging Jobs in Vermont.*[41]**

   Soil conservation and management is vital to conserve nutrient cycles.[42] Logging causes nutrient loss through direct removal of nutrients stored in the harvested biomass, increased erosion, and elevated levels of nutrients leached by stream waters for several years following harvesting.[43] Vermont's Acceptable Management Practices on Water Quality are well-developed and adequate for maintaining water quality.

Aesthetic and Recreation Considerations

1. **Prioritize the safety of any potential individuals who might use the site for recreation.**
   a. Before and during harvesting practices erect and maintain signs notifying recreational users of the harvesting operation and safety concerns.[44]
   b. Consider notifying adjacent landowners as well as the town office of your operation to make the public aware of any potential hazards that may exist.
2. **Maintain the natural aesthetic to the maximum possible extent.**[45]
   a. Maintain a buffer of at least 150 feet between landing areas and any class III or higher roads.[46]
   b. Actively minimize the crossing of hiking trails when creating skid trails. Only cross trails at right angles.[47]
   c. Maintain a buffer of at least 100 feet to hiking and recreation trails, unless absolutely necessary.[48]
   d. Lop treetops 2 feet or less in high use areas. In areas with high deer population, leave slash high enough to protect new seedlings.[49]

The natural woodlands of northern New England have long been an essential part of the region's environmental, cultural and economic identity. These forests are famous in the northeast, as they represent some of the most visually appealing forested lands in the country, particularly in the fall season. Preservation of this aesthetic and public perception, as well as maintaining the ability of the public to use the lands for personal and recreational opportunities is essential to the continuation of northern New England as a sought after destination and a desirable place to call home.

IV. Challenges and Barriers to Achieving Procurement Standards

Setting standards for sourcing Middlebury College's biomass is a complex process, in part because it requires the input of multiple stakeholders. These stakeholders include Middlebury's plant operators and administrators, faculty experts in forestry, members of the Board of Trustees, and various College committees and administrators on sustainability and the environment. But there are important stakeholders in this process who operate apart from the College, including Vermont loggers, other biomass buyers, private landowners interested in biomass harvesting, local experts, and every day citizens concerned about the health and longevity of Vermont's forests. Each of these stakeholders provides a different perspective, and each has a stake in the method of Middlebury's biomass procurement. In this section, we highlight this range of perspectives while teasing out a comprehensive list of challenges and barriers Middlebury College will encounter in setting standards for its biomass procurement. This list is extensive, and where possible, we provide recommendations for how these barriers could be overcome. Due to time limitations, however, the list is by no means complete. Instead, we offer this section as a helpful guide in the beginning processes of establishing a sustainable biomass sourcing system, and we hope Middlebury College will continue to seek out creative, responsible, and realistic solutions to these challenges.

Managing the Supply

A critical player in Middlebury College's biomass sourcing is its broker, Cousineau Forest Products. The College hired Cousineau in 2008 to provide a reliable and affordable wood chip supply to the biomass burner. Before signing its contract, the College expressed a desire for wood chips to be sourced according to the following standards:

- A single supplier of chips within a 50-75 mile radius;
- Chips produced by a supplier certified by the Forest Stewardship Council or the Sustainable Forestry Initiative;
- Chips that were in a price range that would allow the project to go forward; and
- Delivered on demand because the College has no capacity to stockpile wood or chips onsite. [50]

Entering a contract with Cousineau, the College realized that meeting all of these goals was unrealistic in the short term. Cousineau was cognizant of the outlined goals and said it would make an effort to honor these guidelines. However, Cousineau cannot guarantee that these standards are being met, given that it works with multiple loggers who operate on various sites throughout the surrounding region, rather than on one single site. Furthermore, Cousineau also buys wood from smaller brokers, which further complicates transparency. This makes it difficult to track its woodchips to the source and to monitor adherence to our standards on a harvest-to-harvest basis.

Before Middlebury College can implement a new set of biomass standards, we must have a comprehensive understanding of what our operation currently looks like. Where exactly are our woodchips coming from? Who are the loggers who are harvesting the biomass? Are they certified by the Sustainable Forestry Initiative? Are the forest sites certified under Forest Stewardship Council standards? What do the logging operations look like on the ground? Do they practice whole-tree harvesting? How might the standards implemented in these operations compare to VFF's standards? What percentage of compliance might they achieve? After answering these questions, we might find that the standards we've set for harvesting our biomass are being met. Or we may find that the way our biomass is being harvested now is far off the mark. Once we have these data, we can then compare the current situation against our determined standards and begin to work with our broker, among other stakeholders, to make the necessary changes to achieve our standards.

According to Mike Moser, Middlebury's Assistant Director of Facilities Services, Cousineau has been a reliable and essential partner in this endeavor throughout the first year of the biomass plant's operation. The College's contract with Cousineau ends in January 2012, at which point the College will decide whether or not to renew its contract. This decision will depend on Cousineau's willingness to be more transparent about its operation and to monitor its sites. Without full transparency and proper monitoring, there is no guarantee that the College will be able to meet – or even know if it is meeting – the standards it sets.

It is essential that Middlebury College solidify its set of biomass sourcing standards before its contract with Cousineau expires for two reasons. First, the College should give Cousineau ample time to assess the list of standards and determine if achieving those standards is feasible. Second, it is quite possible that our standards will increase the cost per ton of chips to a price that exceeds the amount the College has been willing to pay thus far (See "College Financing" for further discussion); therefore, the College will have to assess the tradeoffs in paying a higher price to meet its higher standards. For instance, if sustainably harvested woodchips are prohibitively expensive, the College may have to prioritize its standards or reevaluate the minimum acceptable percent compliance. However, if Cousineau cannot meet the College's needs, the College should be prepared to seek out a different broker or design a new, innovative system. Possible alternatives are discussed in the section on alternatives supply.

Reliability of Supply

Securing a reliable supply of woodchips for the Middlebury College biomass plant is of foremost concern, to ensure a constant supply of energy throughout the year. Raising the College's biomass procurement standards will inherently restrict our source options and make it more difficult to ensure a reliable supply. As a result, a number of ecological, economic, and social barriers have presented themselves as challenges when attempting to secure access to a constant supply of sustainably-harvested woodchips.

Ecological Constraints

In developing our standards, we've determined that ecological concerns are paramount. The amount of sustainable biomass available for our use, however, will vary

depending on how strict we want our standards to be. For example, according to a study conducted by the Biomass Energy Resource Center (BERC), there are approximately 1 – 1.5 million tons of low-grade, harvestable wood grown in Vermont on an annual basis.[51] Vermont Family Forests has conducted similar studies, in which it estimates that there are 298 thousand tons available for harvest in Addison and Rutland Counties. If VFF were to conduct a similar study statewide, its numbers would fall short of BERC's, owing to its stringent ecological standards. VFF, for example, uses a much lower regenerative growth rate in its calculations, which, in part, explains differences in the forest's calculated capacity.[52] Additional variables that could explain this discrepancy include water buffer distance, slope, and soil productivity.

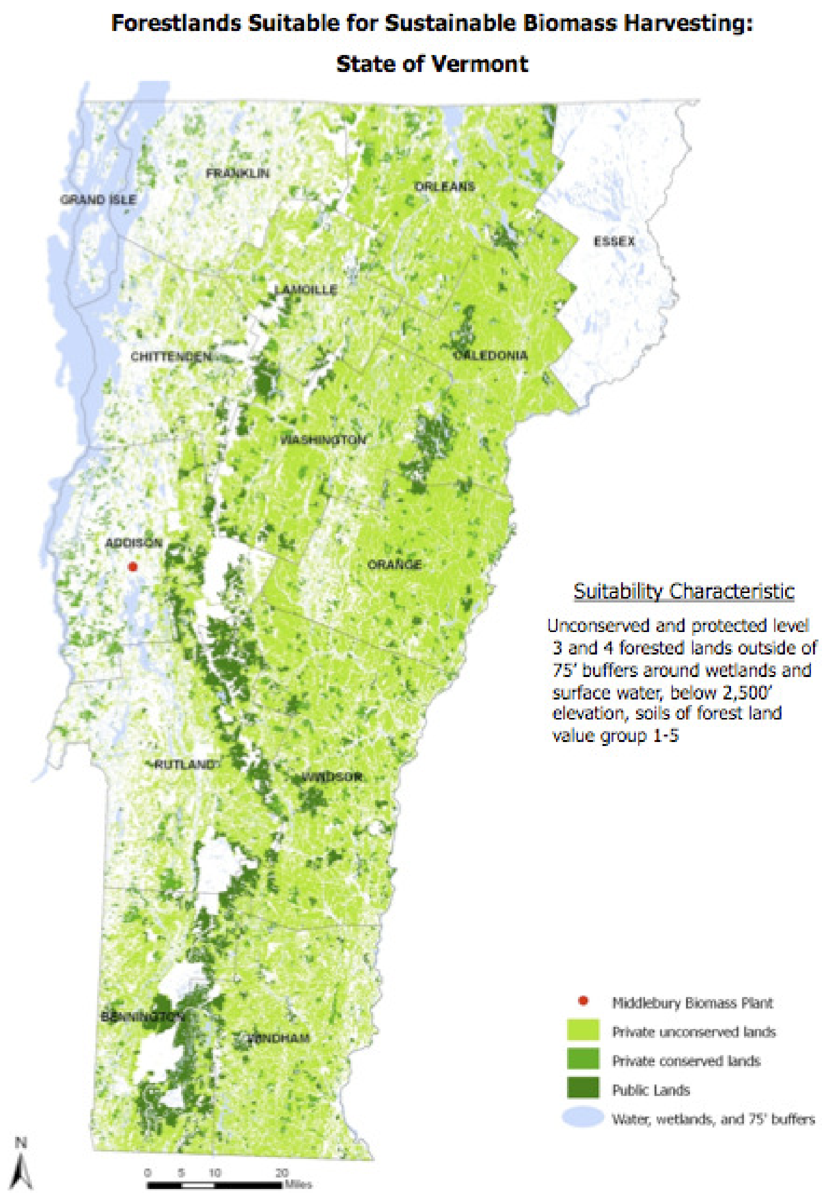

Figure 1: Forests Suitable for Sustainable Biomass Harvesting

In determining what forested lands are currently available for logging activities, we drew from ecological standards developed by Marc Lapin to eliminate certain areas that were not suitable for logging based on the goal of maintaining general forest health and the ecological integrity of certain sensitive ecosystems. The forested lands that appear in Figure 1 are categorized into unconserved lands and lands designated Protection Level 3 & 4, as outlined in the National GAP standards for forest protection.[53] We identify these lands as areas suitable for biomass harvesting, since they may be legally logged under current national guidelines. The ecological standards borrowed from Lapin include the following considerations: soil capability value groups 1-5, elevation below 2,500 feet, and buffering bodies of water and wetlands with a 75 foot barrier. Slope was not accounted for in our analysis due to lack of data. Future research should include this variable. VFF would recommend only including land with slopes of less than 60%, with an optimal range from 0-30%. We have chosen to not include public forested lands in our initial analysis of available forested lands that would be open for logging purposes. There is limited access to public sources and contracts are sold to the highest bidder, usually for high quality timber products. In addition, we foresee the continued use of a broker or third party of some form in the immediate future and, since Cousineau only utilizes privately owned land for its biomass procurement, we decided to focus our efforts on analyzing these lands rather than addressing the utilization of public lands, which seems more difficult considering our current situation.

Transportation

In our current contract with Cousineau, the College requests that all biomass comes from within a 75 mile radius. This standard was dually created to reduce vehicle emissions and support the local logging industry in Vermont and surrounding regions. But since we have no records documenting the exact sources of our wood chips, we cannot determine the level of compliance for this guideline.

In determining a standard relating to maximum trucking distance of our biomass, one question that arises is whether that distance would be measured “as the crow flies” or based on road distance. In Figure 2, we see that defining radii by road distance instead of “as the crow flies” restricts how much biomass is available within certain radii. For example, at a 75 mile radius, this distinction reduces the amount of acres available for biomass harvesting by 500,000 acres (Table 2). Restricting biomass harvesting within a 75 mile radius road distance would reduce the amount of biomass available to Middlebury College. However, in order to stay true to the goal of reducing carbon emissions, it is more appropriate to approach the 75 mile standard as a road length as a more realistic and helpful standard rather than a literal projection that disregards the physical logistics for transporting the woodchips in question.

In addition, it is important to recognize extraneous factors that could potentially affect transportation options thereby reducing the reliability of woodchip supply to Middlebury College’s biomass plant. The most recent example of this type of issue is the closure of the Champlain Bridge, which crosses into New York State, this past October, since our biomass plant had previously received some of its woodchips from New York state.

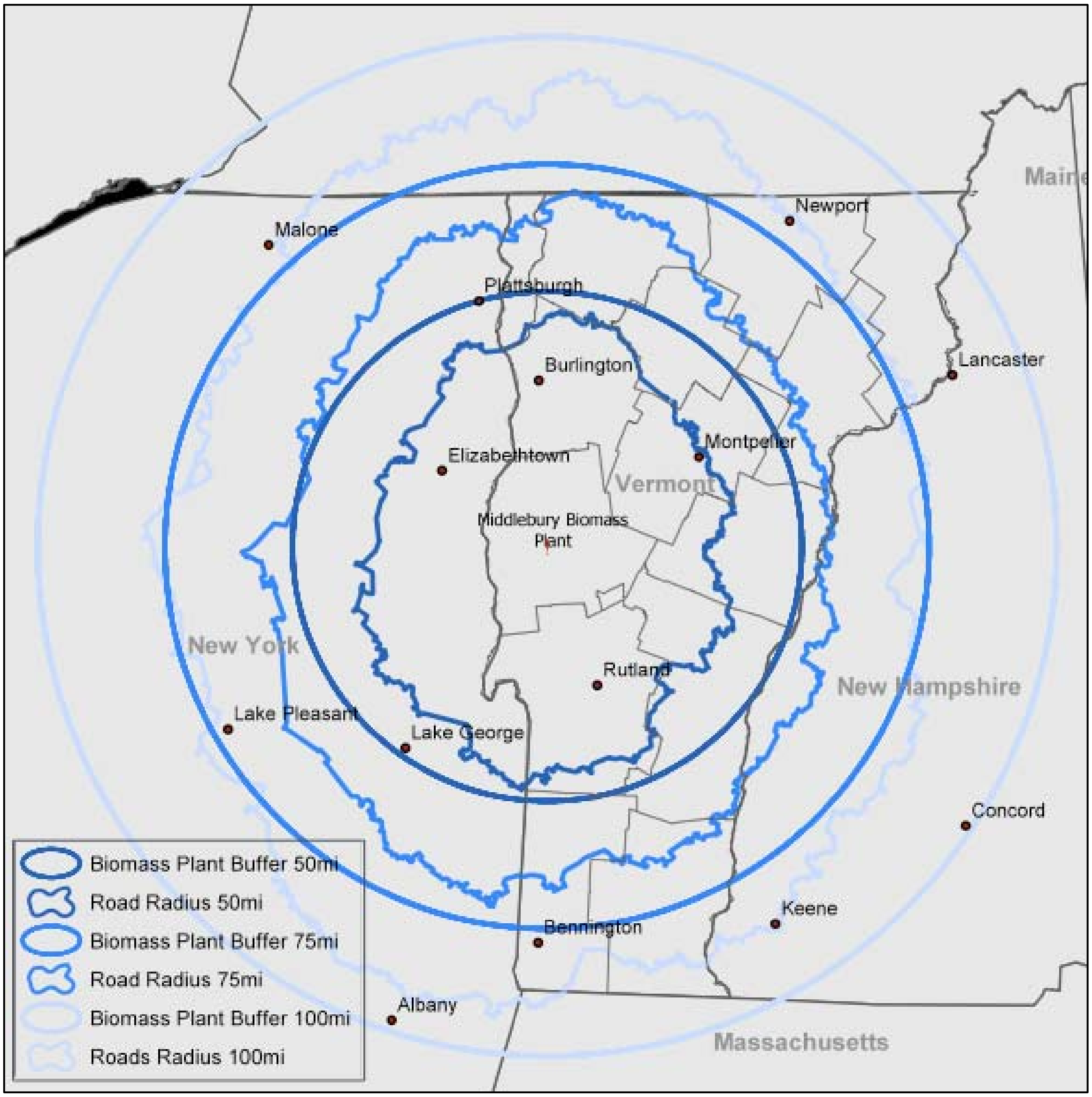

Figure 2: Radii from the Biomass Plant ("As the crow flies" vs. road distance)

	50 Roads	50 Radius	75 Roads	75 Radius	100 Roads	100 Radius
Private Unconserved	585274	1095319	1486215	1968355	2122674	2268596
Private Conserved	75654	128517	178660	214347	230414	241176
Public Conserved	152842	220983	272623	343015	371966	390180
Total	813770	14444820	1937500	2525718	2725055	2899953

Table 2: Acres of land available to biomass harvest in the state of Vermont within specified radii

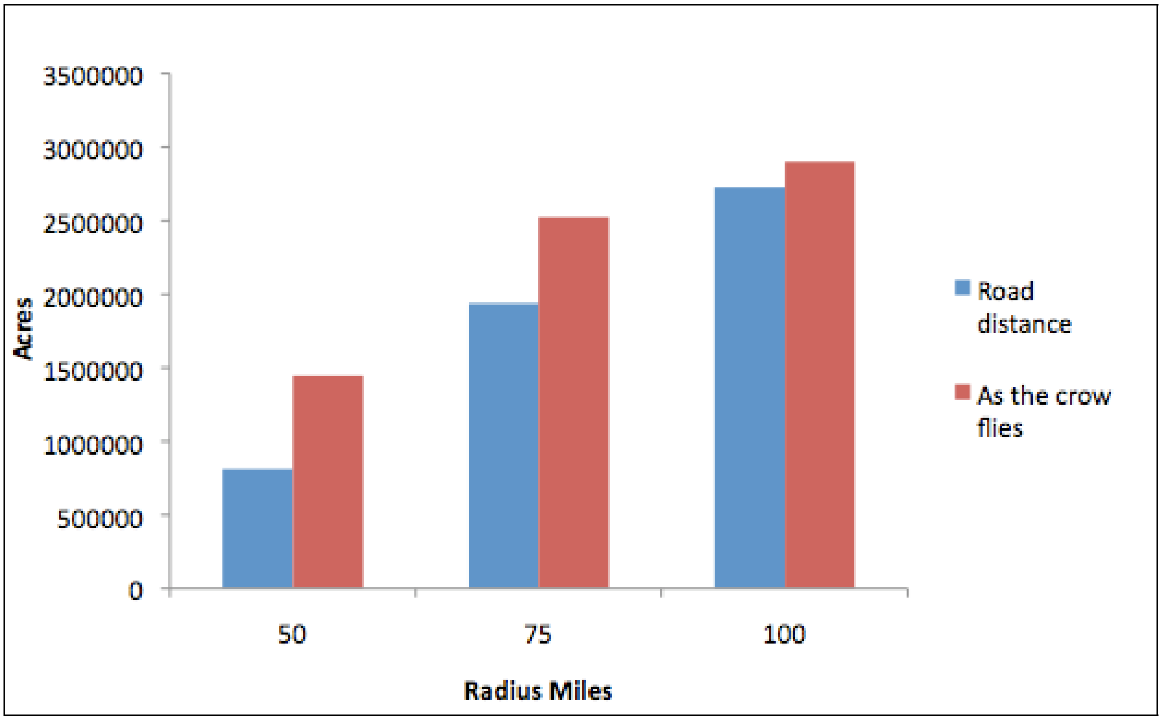

Figure 3: Total acres of land available to biomass harvest in the state of Vermont within specified radii

Diversifying Supply

Private Land Holdings

One of the most effective ways to ensure our reliability of supply and protect ourselves from biomass shortages in the future is to diversify our biomass portfolio. The College could increase the reliability of its supply by working with small private landowners, with the help of our third-party supplier. One notable program that aims to manage and utilize private lands in Vermont is the Use Value Appraisal Program (UVA), in which private landowners agree to manage their forests for timber while following approved guidelines to protect water quality in exchange for a reduction in property taxes. This is especially important for those landowners that have high property values and relatively low income or cash assets. As of 2006, 1.5 million acres of private forested land were enrolled in the program out of the total 3.1 million acres of estimated eligible forested land within Vermont, making it about a 50% enrollment rate. In comparison to the percentage of agricultural lands enrolled in UVA, which includes nearly two thirds of all the farm land in Vermont, UVA forested land enrollment is significantly lower. In order to assess private landowners apprehension regarding enrollment of their land in the UVA program, VFF conducted a survey in which 268 small private landowners clarified what the specific issues were that deterred them from enrolling their land in the UVA program. The top three reasons cited amongst private landowners for refraining from enrolling their land in the UVA program were hesitations regarding giving the government control over management decisions on their land, a lack of information about the program itself, and the stiff penalty for removing their lands from the UVA program once enrolled. While there is room for improvement and growth

within the UVA program, it serves as a helpful starting point for the College in determining which private land holdings might be available for biomass harvesting.[54]

Private landowners in Middlebury's surrounding area offer a range of perspectives on logging and biomass harvesting from their own lands. Though we had only enough time to speak with several private landowners, those we interviewed cited the financial incentive as the main reason why they opened their land to tree harvesting. Their families had bills to pay, and the sale of both saw logs and firewood or other woody biomass helped lessen the burden of their expenses. One man worked directly with Vermont Family Forests to cut from his land, and he said that he was very happy with its standards and with the working relationship. He had a hands-off perspective and let VFF handle many of the logistics. Others did not care as much about the sustainability of the harvest from their land, and were more concerned with the profit margin of their forest products.

College-Owned Lands

Middlebury College itself owns a substantial amount of land around Breadloaf that could potentially be available for logging. The College owns 3,828 acres of forested land. When the College's inaccessible forest lands (swamp, parkland, or research areas) are eliminated, approximately 2,213 acres are under forest management.[55] This land's potential for biomass production has been largely unexplored and could be a potential source of fuel for the biomass plant. The College is currently managing a small portion (425 acres) of its lands for quality mill timber that has been used in the construction of campus buildings such as McCardell Bicentennial Hall and Franklin Environmental Center at Hillcrest. It would certainly be feasible for the College to expand its harvesting goals to include biomass. Even when forests are explicitly harvested for mill quality wood, typically 40% of the harvest is low-grade wood ideal for biomass.[56] Additionally, one project the College may want to pursue in the future is ES 401's (Fall 2008) suggestion that the College use its Breadloaf forests to fuel a smaller-scale biomass plant that provides heat and energy to the Breadloaf Campus.

Logging our own land would be beneficial in that we could closely oversee and monitor the logging practices that were taking place on our own lands. Observing the intricacies and challenges of logging operations could also assist in teasing out the important issues concerning sustainable biomass procurement, current logging practices, etc. Overall, other than having more flexibility and transparency in the monitoring process and harvest scheduling, our College-owned lands would largely be treated as those of just another private landowner regarding both the third party supplier and the loggers involved. These lands could serve as a supply buffer in times when current supply chains are interrupted.

Market Forces Affecting Supply and Demand

Local Demand for Wood Products

Changes in outside market forces at the local, regional, and international scale have the potential to alter or jeopardize the security of our woodchip supply. In the past two-hundred years, Vermont's forests were heavily harvested, providing both high-quality saw logs and low-grade timber for pulp and firewood. These markets continue to

operate congruently; logging operations, by default, produce both high-quality and low-grade timber, and the profits reaped from high-quality sales sustain the Vermont logging industry, making low-grade harvesting economical.

Today, the demand for low-grade wood is lower than it has been in past years, due a high rate of pulp and paper mill ownership turnover and mill closures across the Northeast. In Vermont, loggers and mills are struggling to stay competitive. This poses a big problem for the biomass market, which is highly dependent on the pulp industry.[57] This decrease in the demand for pulp affects the biomass market, increasing the price per ton of biomass. Thus, the biomass market remains dependent not only on the pulp and paper market, but also on the high-quality timber market, making stand-alone chipping operations economically unfeasible. But even the future of the high-quality market is vulnerable; due to the recent economic recession and housing crisis, there is a lower demand for high-quality saw logs.[58]

Local Demand for Low-Grade Wood

An important regional player in the low-grade timber market is International Paper, located twenty miles from Middlebury College in Ticonderoga, New York. If International Paper was to close its paper mill, the demand for timber in the area would decline, thereby decreasing low-grade harvesting and increasing biomass prices. Though national trends in paper production paint a bleak picture for the future, it is still unlikely that International Paper will close; instead, the mill would more likely transfer ownership without ceasing production. However, if the factory were to close, the Vermont logging industry would still have the elasticity to recover after seeing a short-term spike in low-grade timber prices.[59]

Local biomass procurement also has the potential to conflict and compete with the local firewood supply market, impacting the reliability of the local biomass supply. Both biomass and firewood rely mainly on low-grade harvesting. Since firewood makes a greater profit than other forms of biomass, loggers may prefer to sell their low-grade timber as firewood rather than biomass. As long as loggers can sell low-grade wood more profitably as firewood than biomass, firewood will remain their priority. The firewood market is significant in Vermont; it is approximated that between 600,000 and 700,000 green tons of firewood are sold annually in the state (*cf.* Table 3).[60]

Local Demand for Biomass

Middlebury's biomass demand is minimal in comparison to the statewide biomass demand. For example, the McNeil Station in Burlington uses between 200,000 to 400,000 green tons compared to Middlebury's 20,000 green tons per year.

Other nearby establishments, including Porter Hospital, Middlebury Town, and Green Mountain College, forty miles from the College in Poultney, VT, are also considering using biomass to meet their future energy needs. Their entry into the local biomass market could have a significant impact on the availability of woodchips for the College's biomass plant, especially if the biomass procurement industry does not grow with the same speed and intensity as the level of demand for those products. With other large stakeholders entering the biomass market, resources and consistent access to woodchips could be strained if the demand far outweighs the supply. However, their entry into the biomass market, in the long run, would increase the demand for biomass

making it a more viable stand-alone industry, attracting more loggers to focus solely on biomass procurement. This could foster the development of a more diverse and sustainable supply of woodchips available for the College's biomass plant. There is a need for oversight to assure the responsible growth of this industry. Efforts by the state legislature could serve in this capacity.

Consumer	Green tons per year
Residential firewood	600,000 – 700,000
Joseph McNeil Power Station (Burlington)	200,000-400,000
Ryegate Power Station (Ryegate)	250,000
Local schools	36,000
Middlebury College	20,000
Bennington College	4,000

Table 3: Local biomass demand by current consumers [61]

International Market Forces

Over the past few years, the global trade of wood raw material has significantly developed and has had an influential effect on the market demand and prices for biomass. In 2007, the global trade of wood biomass was just over 11 million tons, with major trade flows most active within the European continent and between Canada and Western Europe.[62] Much of the increase in shipments is the result of policies implemented by European governments to generate more green energy based resources as substitutes for fossil fuels in order to fulfill their 20% target for renewable use by 2020. As a result of European green policy initiatives, biomass is now the largest renewable resource in use in Europe, forming almost two-thirds of energy supplied in the fast growing renewable sector and accounting for around 5% of total energy consumption.[63]

The recent expansion of the biomass industry in Europe has led to an increase in the demand for wood raw materials. Due to this increase in demand, the biomass industry is increasingly relying on pulpwood and woodchips for its raw material needs, as the supply of lower-cost sawdust cannot meet the fast rise in demand for wood fiber. As a result, the biomass sector in Europe is now competing with both the wood-based panel manufacturers and pulp mills for wood residues and logs, thus forcing wood fiber prices to increase. The recent evolution of the wood raw material market in Europe is not unique to this continent, but can also be expected to take place in North America, and specifically, can be expected in the local markets of Vermont. Applying this analysis from the European markets, an expansion of the Vermont biomass industry could cause prices of all wood raw materials in the market to rise due to the increase in competition.

In addition, as Europe currently imports a large amount of wood material for energy production, European demand for biomass and wood products could directly affect the New England and Vermont markets. [64] In the first quarter of 2009, Europe imported $100 million worth of wood pellets and wood fuels.[65] Increased outside demand could affect the market and price of biomass in Vermont as international players demand more wood-based alternative energy by 2020 and onwards.

College Financing

Beyond exterior market forces, economic and financial concerns exist at the College level. In order for our standards to be adopted by the College, we will need to garner support from the College administration. Financing any additional costs contingent to introducing biomass procurement standards is of particular concern to this administration at this time, given the global economic recession. One reason that the current biomass plant was approved is that shifting a large portion of the College's energy source from #6 heating oil to biomass wood chips generates significant savings. These savings would eventually "payback" the original investment of $11,900,000 to build the plant over a number of years (based on the price of oil and biomass chips). Under a model where #6 heating oil costs $1.75/gallon (Middlebury paid $1.76/gallon in September 2009) and woodchips cost $38.50/ton (as they do in the current Cousineau contract), the biomass plant project generates an internal rate of return (IRR) of 11.2% and a payback period of 9 years. This means that the savings generated from the switch from oil to biomass will repay the original investment of $11,900,000 for the plant in approximately 9 years. An IRR of 11.2% represents an annualized rate of return on the initial investment over time, from savings, if the net present value of the plant investment is 0 over its lifetime of 40 years. The net present value (NPV) of the original investment is just under $14 million in this scenario.

For the Administration to support more robust biomass procurement standards, which may increase the price of woodchips, it is important to measure how increased prices might affect the IRR of the original investment in the biomass plant. This IRR should stay as close as possible to the current 11.2% and should not fall below 5.0%, which is the interest rate on the loan taken out to finance the biomass plant.[66]

Beyond how an increase in the price of chips may decrease the savings generated by the biomass plant, an increase in oil prices increases the savings generated. Given the volatility of oil prices over the past 25 years, it is reasonable to assume that the savings generated by shifting away from oil and towards renewable energy sources like biomass woodchips could be even higher than savings calculated when oil cost 2009$1.50/gallon. Over the past 7 years, #6 heating oil – a.k.a. residual fuel oil – prices have ranged from 2009$0.81/gallon in the 2002 to 2009$3.59/gallon in June 2008 (Figure 4). There has been extreme price volatility between January 2005 and January 2009 alone. Residual oil cost 2009$1.22 in January 2005, 2009$3.59 in June 2008 and 2009$1.24 in February 2009. Current projections from the Energy Information Administration do not suggest that the price of oil will be any less volatile in the future; residual oil in January 2010 is currently projected to cost between $1.45 and $2.47 per gallon. [67] Oil prices are currently depressed due to the current global economic recession. Therefore, oil prices could increase as the global economy rebounds from the recession in the coming years.

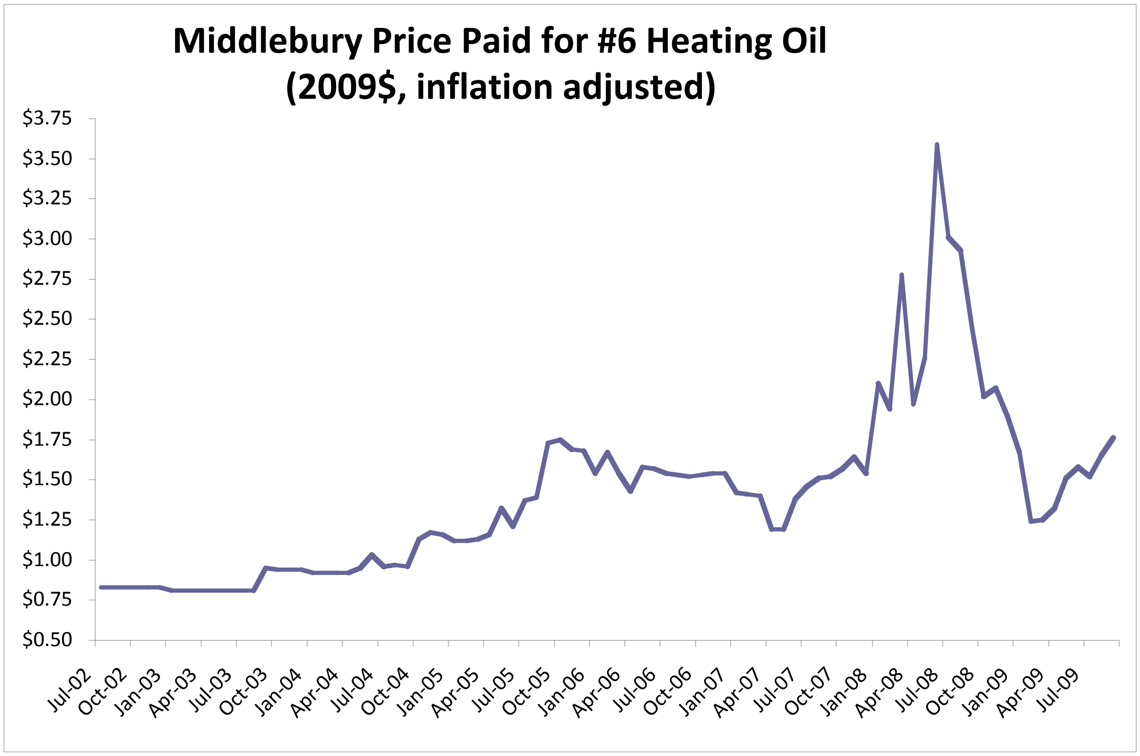

Figure 4. U.S. Residual Fuel Oil Retail sales by All Sellers (Dollars per Gallon)[68]

In order to get an accurate picture of potential future savings from the biomass plant, we looked at various oil-price scenarios, $1.50, $1.75, $2.00 and $2.50/gallon, to estimate the maximum price that Middlebury College could afford to pay for biomass woodchips. We found that Middlebury College could spend a maximum of between $52.77 and $106.38, if the Board were willing to reduce the potential IRR to its 5% minimum; $52.77 would be the maximum if oil were to decrease to $1.50/gallon, whereas $106.38 would be the maximum biomass price if oil prices were to increase to $2.50/gallon. The maximum price for biomass based on varying prices of oil and rates of return are depicted in Figures 5 and 6 below. In a scenario where the price of residual fuel oil remains at $1.75, Middlebury could afford a chip at a maximum price of $58.21, without reducing the IRR of the project lower than 7%, still higher than the interest rate on the loan taken out to finance the project (5%). This price is almost $20 more expensive than what Middlebury is currently paying. It is clear that Middlebury will be able to afford a more expensive, sustainable chip. How much more expensive will depend on future changes in the price of residual fuel oil and how willing the College is to reduce the IRR on the initial biomass plant.

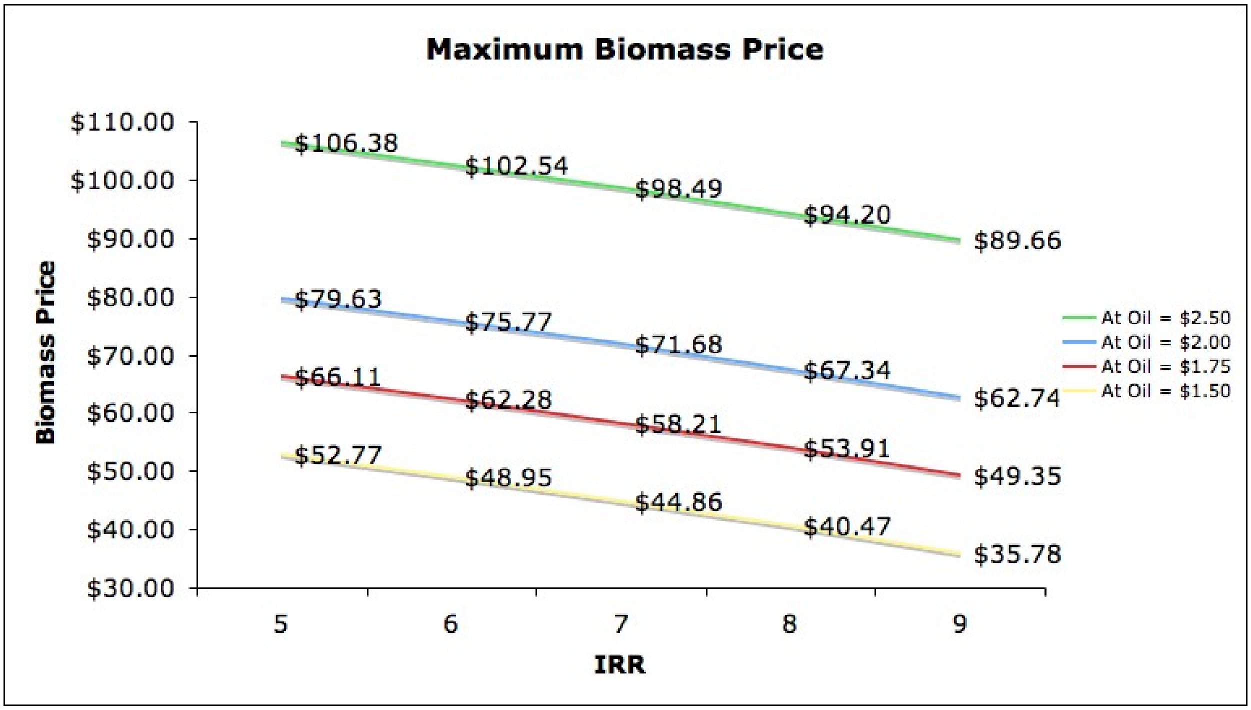

Figure 5: Maximum Biomass Price (Biomass Price vs. IRR)

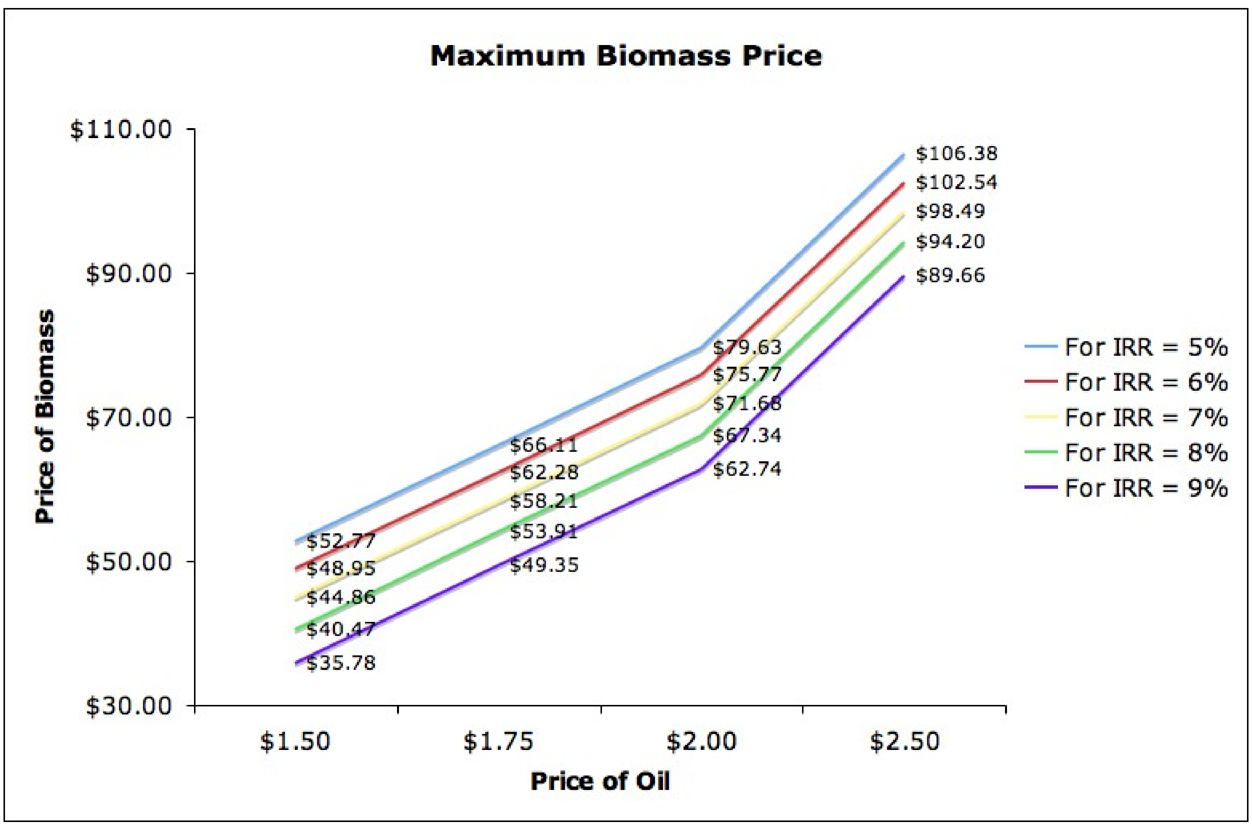

Figure 6: Maximum Biomass Price (Biomass Price vs. Price of Oil)

Community Relations

Beyond the reliability of supply, when developing our standards for the College's biomass procurement, we must consider the impact that the plant has on the logging industry and the surrounding community. As a leader in sustainability and as the first College to build a biomass gasification plant, Middlebury College has received quite a bit of public and media attention regarding the facility. Thus, the College's commitment to this endeavor is heavily scrutinized, and the College does itself a service by adopting high-level standards for the sustainability of its woodchips.

To gauge public opinion about the College's biomass plant, we ran a two-week poll in the *Addison Independent*, posting the following questions:

- What do you see as the greatest benefit of Middlebury College's new biomass facility?
- What, if any, is your greatest concern regarding Middlebury College's biomass facility?

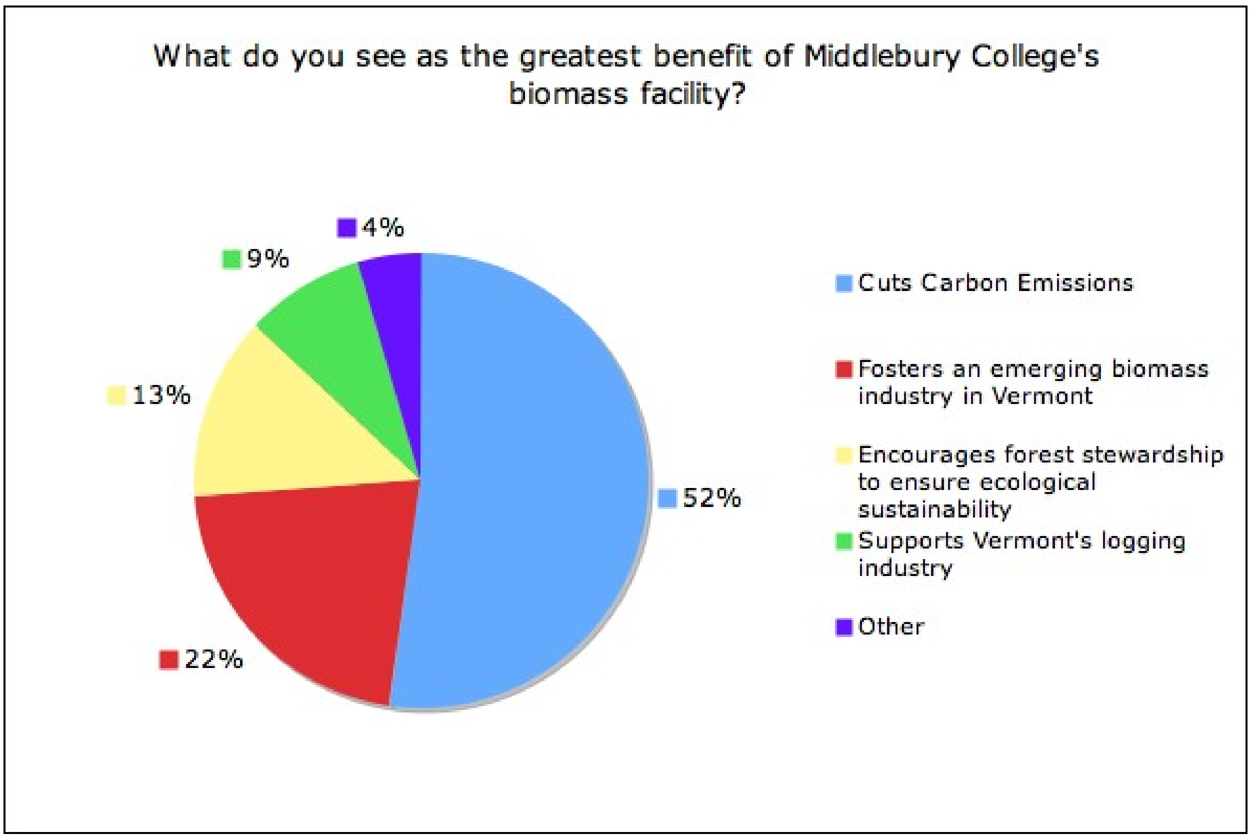

Figure 7: Addison Independent Biomass Poll Results. N=26

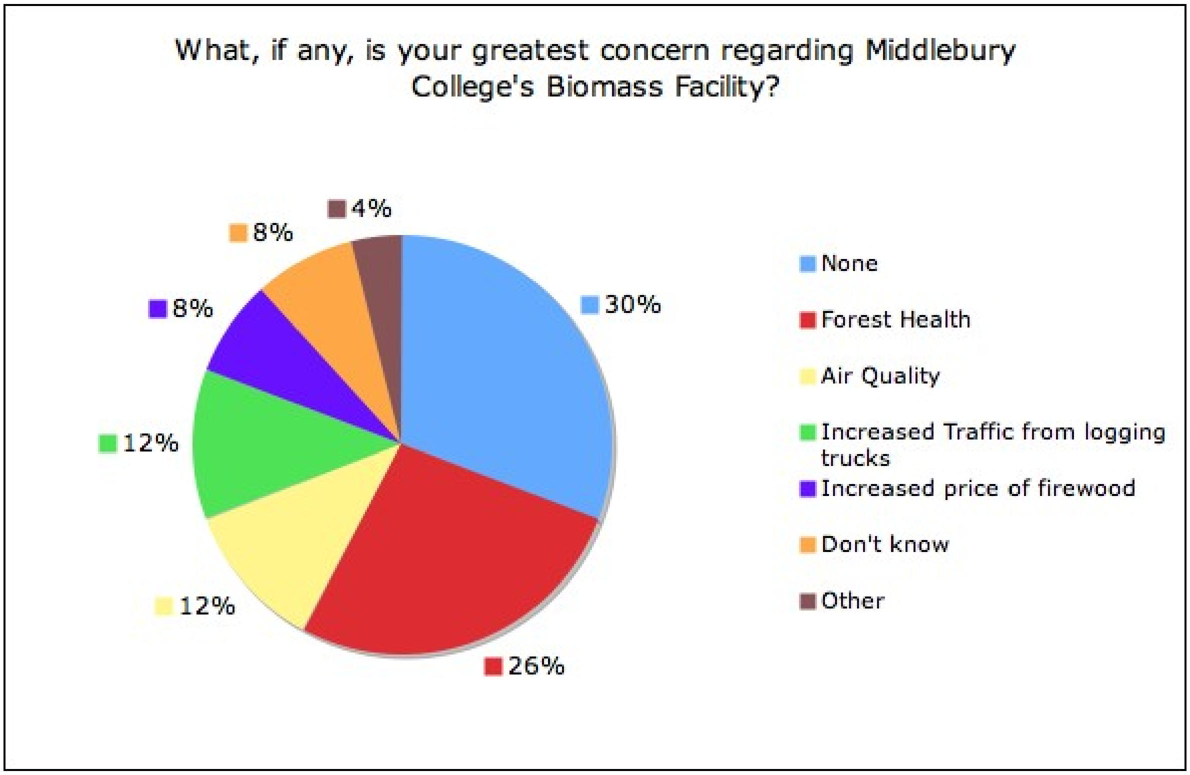

Figure 8: Addison Independent Biomass Poll Results. N=26

Of the twenty-six respondents, 52% chose "cutting carbon emissions" as the greatest benefit to the facility. In response to the second question, 31% chose "no concern," and 26.9% chose "forest health" as their greatest concern. Twenty-six percent of respondents said they had other concerns but none of them shared the nature of their other concern. Although our sample size is small, these statistics help to illustrate that multiple community members understand the importance of the switch to biomass.

In addition, the College must determine to what degree it is responsible in supporting fair wages for loggers. The local logging community has come under some pressure in the recent past. There has been a decline in the demand for high quality wood. In Vermont, it is largely the high quality wood market that carries the biomass market (See "Reliability of Supply, Market Forces Affecting Supply and Demand").

According to Larry Altman, a local logger from Bristol, selling biomass in Vermont is not economically feasible. Altman makes around $12 per cord, versus making $25 a cord when he sells it to a buyer in Maine, the difference being what party pays the trucking costs. In order to support local loggers and ensure future supply of biomass, we need to consider this social component of our biomass procurement.

Case Study: Local Logger Larry Altman's Costs Breakdown		
	Biomass sold in Maine	Biomass sold In Vermont
Gross Revenue	$25	$25
Trucking Costs	-$0	-$13
Net	$25	$12

Table 4: Local Logger Cost Breakdown

V. Monitoring

The adoption of biomass procurement standards for Middlebury College is a crucial step for the College as it tries to ensure that the chips for our biomass plant are as sustainable as possible. However, while the College's mere adoption of standards is a positive and necessary step in the right direction, the College's standards have the potential to become superficial and meaningless if they are not effectively enforced and monitored. It is for this purpose that a large component of our project revolves around this implementation and monitoring piece, so we can ensure that our standards are being effectively put into place in the field.

Context

In crafting our biomass monitoring program, we first researched and evaluated various monitoring schemes both inside and outside the forestry sector. Within the forestry sector, we looked at the evaluation programs of the FSC and the SFI, both which involve external accreditation and certification audits. Outside the forestry industry we researched several well known certification programs such as Fair Trade, USDA Organic, and the Food Alliance.[69] Both the USDA Organic and Food Alliance programs involve third-party site visits, but the Fair Trade program was interesting in the fact that its evaluation process relied on self-monitoring assessments and internal audits.
It is important to note that essentially all of the monitoring programs we examined are national and international in scope and hence operate on a much larger scale than the Middlebury College biomass plant.

While such large organizations can often end up with poor monitoring practices, simply because of the large size and scope of their efforts, Middlebury College is in the unique situation of having a relatively localized operation and thus has the potential to effectively and rigorously monitor its standards in ways that large organizations cannot. Unlike self-monitoring programs, Middlebury College would benefit from a third-party monitoring system that would lend credibility to the enforcement of the College's standards and allow the school to perform oversight and track compliance levels with greater ease and reliability. This system would provide the College with a level of direct control that would be lost in a self-monitoring scheme based on the subjectivity and personal discretion of individual loggers.

Looking at such examples of existing monitoring schemes brought to light several key points and questions for our consideration, including: Who should carry out our biomass monitoring? A third-party like most of the programs we examined or the loggers themselves? Also, when in the process shall we monitor sites? Before they are logged, while they are being logged, or after they are logged? Should our monitoring visits be random or scheduled? It is these questions, along with many others, that we attempt to answer and address in the remainder of this section.

Costs and Monitoring Scenarios

The monitoring of forest logging sites is imperative to ensure the implementation of Middlebury College's standards and in recording the progress of harvesting operations. These monitoring scenarios and the following metrics are applicable to a forest logging site and cannot be applied if wood is procured second-hand in other scenarios discussed such as mill residue or stump dump material (See Alternatives to Supply Section). There are four monitoring scenarios that have been laid out as feasible for Middlebury College to pursue: relying on self-monitoring on the part of Cousineau; adding a College land manager staff position; hiring a third party, outside consultant to visit the logging sites; and creating a student intern position to complete this task.

Cousineau Monitoring

One monitoring option would be to simply include Middlebury College's biomass procurement standards in the contract and leave the enforcement of this to Cousineau. This would be the easiest scenario for Middlebury College since it would not require further work or analysis on its part. The problem lies in the fact that, as discussed with Cousineau representative Jon Baker, Cousineau deals with the sub-contractors and not directly with the loggers and landowners. It is assumed that Cousineau would pass on the standards with an agreement that they be followed, but there is no guarantee and the College would not be in a position to verify this if monitoring power was given to Cousineau. Simply relying on Cousineau to complete self-monitoring does not assure standards would be enforced. If Cousineau *were* able to attempt to receive relayed reports it would present additional costs to the College.

Staff Land Manager

Hiring a staff land manager position to also function as a College forester is an intriguing option; however, this would have to be more of a long-term plan since the College is currently unable to add a new staff position due to financial constraints. Based on an estimate from the Middlebury College Human Resources department for an employee with the necessary certifications and 3-5 years prior experience, this option would cost $60,000-$70,000 for a full-time salary position, including benefits. It would be very helpful for Middlebury College to have a full-time employee focusing on this as a part of his or her job responsibility and the individual hired would be skilled and knowledgeable in forestry. Adding this position would ensure consistency in monitoring of standards since the same individual would be in charge of tracking progress. The College would also acquire a great deal of knowledge and thus be able to accurately report and be accountable for its biomass logging. The land manager would be a strong monitor since he or she would provide information directly to Middlebury. However, this is currently an unrealistic scenario due to the hiring freeze, and based on conversations with Tom Corbin, unrealistic to consider in the budget.

Third Party Consultant

Hiring an outside consultant would bring in the knowledge of a trained forester, provide the enforcement capability that working purely through the Cousineau contract

would lack, report directly to the College, most likely monitor consistently and would be less expensive than adding a full-time staff position. Based on discussions with Burlington Electric forester Bill Kropelin and David Brynn of Vermont Family Forests, an outside consultant forester would cost $75 per hour including overhead costs. Both Bill Kropelin and David Brynn estimated that a site could be checked in around two hours. Another two hours of work would be required to perform the necessary administrative work associated with the site visits and tracking of compliance. The number of site visits is very difficult to estimate since Middlebury College is currently unaware of the number of logging sites from which we obtain biomass. We estimate two visits per site per cut: one to assess the current logging practices and establish a baseline and one more to see if recommendations had been implemented. If there are between 20 and 30 different logging sites, this would translate to approximately 40 to 60 site visits per year. This would be a cost of between $12,000 and $15,000 dollars per year for the salary of the consultant.

Student Position

A student monitoring position could be filled by an intern with expertise in field ecology. This would cost $9.30 per hour (a level C Middlebury College student job) plus the same estimated overhead costs so yearly salary cost would be reduced to between $4,000 and $6,000. This scenario is difficult because it would involve a team of two to three students who would most likely change yearly, so there would not be as much consistency in the work from person to person or year to year. The standardized checklist would help to eliminate some of this, but it would not be the same as a consultant repeatedly working with the checklist and gaining a personal knowledge of the College's standards and monitoring system. Taking photographs to compare would also help with this issue, but students still lack the skill set of a trained forester. It is also a very big project and it may be asking an unrealistic time commitment for students.

Students could also be introduced to the monitoring by incorporating a forest site visit into the Environmental Studies 112: Natural Science and the Environment class. This would not only educate students about sustainable forestry but also help them see the direct impact of the biomass and their heating demands. This sort of visual, hands-on experience would be an important piece in raising campus awareness as to the implications of harvesting biomass and the importance of efficient energy use. Students could also be introduced to the monitoring early in their academic career to then consider pursuing this if there were a student intern position available for a senior.

Hybrid Scenario

Finally, a hybrid-monitoring scenario could be established that combines the options of a third-party consultant forester and a student position. Based on a conversation with Jon Baker, it would be possible, at no additional charge to the College, to obtain logging tickets for each truckload that comes in. These tickets are a common practice, and they document the town and cut site, the logger, and the sub-contractor, as well as the contractor's contact information. The student position would begin by calling the contractors to find out the exact locations of cuts that ship biomass to Middlebury College. Then, the student would compile this information and pass it on to the consultant forester. The forester would go out on-site, equipped with the monitoring

checklist, and fill out all of the necessary information for the estimated 2 hours per site visit. Once the job was finished, the completed monitoring checklists would be entered into a database by the student position. This could even be added to the Middlebury College website for increased transparency. The price for this option would be the total cost of a consulting forester plus a student position with much more minimal hours. If students worked the estimated 2 hours of administrative work per site and were paid a Level B Middlebury College student salary ($8.70/hr), this would bring the total cost to between $7,000 and $11,000.

In the College's current situation, the most realistic and cost-effective option that will bring the most professionalism and consistent monitoring is to hire a third-party consultant, with the hybrid approach that includes a student position. The consultant will study the College's standards and use the Middlebury College monitoring checklist to perform random checks at the logging sites. The College, with the help of the student position, will track the compliance and through the forester's interaction with the loggers on site, encourage and enforce the planned increase in compliance.

Monitoring Scenario	Pros	Cons	Costs
Cousineau Forestry Products	Simple, no need to hire third party	Unrealistic	n/a
Staff Land Manager	Best serves Middlebury's interests	Too expensive, hiring freeze	$60,000-$70,000 full-time salary, including benefits
Third-Party Forester	Forestry experience and outside perspective	Difficulty of coordination	$12,000-$15,000 yearly salary
Student Position	Inexpensive, educational opportunities	High turnover rates, unskilled workers	$4,000-$6,000
Hybrid: Consulting Forester and Student	Forestry experience, coordination	Complicated	$7,000-$11,000

Table 5. Viability of monitoring scenarios weighted against pros, cons and costs of each

Implementation

It is difficult at this point in time to design a definitive monitoring implementation strategy, simply because we do not, at this time, have an appropriate picture of what the current practices look like and hence have no baseline that we can continue to improve upon. After speaking over the phone with Jon Baker at Cousineau, it is evident that this information could be available in the future. Due to this current lack of information, we

recommend that for the first two years in which our new standards are in place, we monitor sites solely for the purpose of establishing a baseline by determining the current level of compliance amongst our biomass suppliers. We realize that it is impractical to aim for 100% compliance with our standards and even that individual compliance may vary on a job-to-job basis, so we recommend the adoption of an end compliance goal of 85%.

We recognize that it is unrealistic to assume that all loggers at all sites will immediately be able to comply with each of our standards. It is for this reason that we recommend that our standards be phased in over a period of 10 years. This will allow ample time for loggers to become adequately acquainted with our standards and have time to adjust their habits and practices accordingly. Although, as suggested above, the current rate of compliance with our standards is unknown, we have developed a number of model phasing-in scenarios in accordance with our recommendations above that can be adopted after an initial baseline has been determined. After determining the compliance level of each logger, we will expect the compliance rate to increase to 85% over the 10-year period as described in Table 6 (See Appendix A).

Compliance Ramp-up Scenarios

Many monitoring and enforcement cases that we have evaluated rely upon heavy-handed, antagonistic compliance strategies. While our primary goal in monitoring is indeed to ensure compliance with our standards, it is our intention for our enforcement process to be a cooperative endeavor between monitor and logger, and we have consciously designed our monitoring process around this notion. As described above, we have designed our monitoring ramp-up scenario to be phased in following an initial two-year information-gathering period. It is our hope that during this time, in addition to determining a compliance baseline, our monitors will have the opportunity to work with the loggers in familiarizing themselves with the new standards, becoming accustomed to them before the pressure exerted by the compliance ramp-ups is in place. In addition to conducting field evaluations of logging sites, our monitor will dually act as a resource and educator for the loggers, providing guidance and support as the loggers make efforts to reach compliance.

In order to incentivize our compliance increase over time, we will offer a system of bonuses that will be paid retroactively to loggers for jobs that obtain a high level of compliance. By adopting such a reward system (as opposed to a system of disincentives and sanctions), it is our hope to further encourage a friendly relationship with our loggers rather than an antagonistic one in which our monitors are perceived as filling a policing role. It is hard to outline a definitive scheme at the moment simply because we don't know what the current compliance levels are, however we envision a system that provides these monetary bonuses to the top 5% (for example) of our biomass suppliers. The bonuses would potentially be on the order of an additional \$5-\$10 per ton. These bonuses will be given at the end of every year and will be re-allocated on a yearly basis. The College will begin implementation of this incentive program after the 2-year initial monitoring period and once the compliance phase-in begins.

Baseline										**Target**
	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	**Year 10**
20%	27%	33%	40%	46%	53%	59%	66%	72%	79%	**85%**
40%	45%	49%	54%	58%	63%	67%	72%	76%	81%	**85%**
60%	63%	65%	68%	70%	73%	75%	78%	80%	83%	**85%**
80%	81%	81%	82%	82%	83%	83%	84%	84%	85%	**85%**

Table 6: Compliance ramp-up scenarios for various baselines.

Monitoring Procedures and Monitoring Checklist

In order to uniformly and quantitatively assess the degree to which the loggers providing Middlebury's biomass are adhering to our standards, we have created a field checklist to be used by the College's monitor when conducting site visits. The checklist contains 14 monitoring criteria that have been taken directly from the procurement standards as well as the Vermont Water Quality Acceptable Management Practices (AMPs). The field monitor will evaluate every site based on each criteria and in accordance with the AMPs, and each criteria will be given a rank based on a 1-5 scale, where 1 is the lowest level of compliance and 5 is the highest. Ranks will be determined using the following criteria:

1) A score of 1 should be given when compliance is essentially non-existent or is very poor.
2) A score of 2 should be given when compliance is present but is minimal and unsatisfactory.
3) A score of 3 should be given when compliance is average.
4) A score of 4 should be given when compliance is satisfactory but still somewhat below standard.
5) A score of 5 should be given when there is full compliance with the standard.

After completing the monitoring checklist, the monitor will total the scores for each category, coming up with a single point total (maximum of 70). Percent compliance will then be determined by dividing this value by 70. While completion of the checklist will be mandatory for every job, the monitor is also encouraged to take photos to document particular aspects of the site visit or obtain any supporting materials that he/she deems helpful.

In addition to phasing in our standards as outlined above and ramping-up toward our final compliance goal of 85% (or 60 points on the monitoring checklist), we plan to ramp-up minimum compliance over time as well. By Year 5 of the phase-in, no "1" scores will be acceptable, and by Year 10, no "1" or "2" scores will be accepted.

We recommend that each site be monitored one time per cut, and in order for us to get the most realistic picture of logging practices, sites should be monitored randomly (unannounced) at a time during the cutting (as opposed to before cutting has commenced or once cutting is completed). While this is our ideal recommendation, we realize that because of external constraints such as time and funding, the number of sites we visit could be potentially limited. If this ends up being the reality, and we are only able to visit

a portion of the sites from which our biomass is harvested, it is our priority to monitor at least one site *per logger* every year. We think that it is fair to assume that a logger's practices will be fairly consistent in all of his/her cuts, and under the likely constraints, this scenario would allow us to most effectively gauge compliance. Furthermore, because we plan to allocate bonuses to those loggers who exhibit excellent forestry practices and compliance with our standards, it is necessary for equity's sake that we monitor a job of every logger.

Although we have tried to craft a monitoring plan that will ensure to the best of our ability that our standards can be feasibly met, we recognize that we are bound to encounter cases of non-compliance. In such cases, we recommend that the monitor speak with the logger about the violation and conduct an additional site visit either during or immediately following the cut, at which point the logger must demonstrate improvement. Once again, we realize that situations will vary on a case by case basis, and it is our goal to work constructively with loggers when problems are found and give them a fair chance to improve their practices. This being said, if a logger shows a particular negligence toward our standards and fails to improve his or her practices in a manner acceptable to the monitor in a timely period, the final ramification will be losing his or her ability to provide biomass to the College.

VI. Implications for Carbon Emissions

When students, faculty, and administrators set out to develop a carbon neutrality plan for the College, Middlebury's reputation was their selling point, but moral obligation was their motivation. With global warming becoming a more imminent threat, the College had a responsibility to do its part and set a standard for other institutions seeking emissions reductions. The launch of the biomass gasification plant in February 2009 was the College's impressive first step toward this goal. In the College's "Sustainability Policy for Biomass Procurement," Jack Byrne begins the introduction by stating, "Middlebury College has set a goal of becoming carbon neutral by 2016 as a result of its concern about global climate change from human caused emissions of greenhouse gases." Thus, the College's carbon neutrality goal and investment in the biomass facility have unarguably been linked from the beginning. Though Middlebury College's definition of carbon neutrality is limited to those processes and emissions that occur on campus, we believe the College still has a responsibility to reduce its carbon footprint along the entire chain of supply, from the cutting of the trees, to the transportation of our biomass, to the regeneration of the forest.

As we develop standards for our biomass procurement, it is essential that we consider our impact on the natural carbon cycle and the forest's capacity to regenerate itself. Carbon cycling is essential to biomass generation and net primary production, the cycle beginning with photosynthesis fixing carbon within the growing tree. When the tree decomposes, it forms carbon-saturated humus, from which the carbon is eventually released back into the atmosphere. If we consider the biomass burner as a part of this cycle, the burner is essentially speeding the release of carbon into the atmosphere, rather than allowing the biomass to decompose and release carbon at the pace of its natural cycle. This concept brings into question whole tree harvesting: if a whole tree is chipped, and no biomass is left to decompose within the forest, not only is nutrient cycling

disrupted, but the carbon cycle is sped up considerably, perhaps beyond the forest's capacity to speed its rate of carbon sequestration. Leaves also contain a significant portion of a tree's fixed carbon, and burning these leaves along with woody biomass strips important nutrients from the forest's natural cycles.

Another important interplay between biomass harvesting and carbon sequestration is the variability in sequestration potential among different forest types. Different tree species vary in their capacity to sequester carbon. In addition, a forests' climate can increase or decrease its growing season; the lengthening of a growing season is generally correlated with greater biomass generation, and greater carbon sequestration. Thus, a number of abiotic and biotic factors affect the carbon cycle – and we have the potential, for better or worse, to augment or reduce these factors with our sourcing practices. These are factors that could influence whether burning biomass is actually a carbon neutral venture.

Our standards should be such that any biomass harvesting Middlebury College commissions should improve on the forest's ability to capture and store carbon. But how do we know when the forest is producing above this threshold? Our short-term suggestion is to follow Vermont Family Forests Director David Brynn's advice: set a system for monitoring not only sustainability practices in our biomass procurement, but energy consumption and carbon emissions. To do so, the College could measure carbon through a combination of biometric surveys of carbon fluxes over long term intervals and ecological process studies over short term intervals.[70] Then, over time, we'll have a set of real numbers to work with, and we'll be able to narrow our standards using parameters we derive from the data. These numbers could indicate whether or not the College's biomass procurement is carbon neutral, and could illuminate the ways we could better achieve our carbon neutrality standard.

Monitoring Carbon Emissions

It is important in all of these monitoring procedures that we also address the issue of carbon emissions. Middlebury College touts the fact that the biomass plant is an improvement because the forests sequester more carbon than is removed through harvesting and burning in Middlebury's biomass facility. The biomass plant represents a large piece of reducing the College's carbon footprint, in order to meet the goal of carbon neutrality by 2016. However, there is currently no monitoring in place or verification of the biomass plant's carbon neutrality. In an effort to establish a baselines as well as information for monitoring in the future, some numbers for carbon emissions have been investigated as a preliminary step toward calculating the College's carbon footprint related to biomass.

Based on an average College biomass moisture content of 36% derived from data in September and October, burning 20,000 tons of chips in one year will release 7,350 tons +/- 540 tons annually, which is about 17,000 tons of carbon dioxide.[71] These 20,000 tons of biomass have replaced 1 million barrels of #6 fuel oil. The fuel oil burned was releasing 12,500 tons of carbon dioxide each year. It is important to take into account that the biomass carbon calculations are based on a senior-year thesis that is still in progress, and therefore the estimates are still rough. As far as calculating transportation and chipping costs, it is very difficult to make these calculations without knowing where the wood is coming from. Per a conversation with Jon Baker, he mentioned that Cousineau

is likely getting its wood from within the 75-mile radius in the contract, because to be outside of that radius is not cost-effective. However, he did not know what percentages of the College's chips are coming from within the radius.[72] Middlebury receives three shipments of chips per day and using a conservative estimate of 150 miles per shipment based on the 75-mile radius; based on an estimate of 10 mpg for the logging trucks this adds another 45 gallons of gasoline per day to the carbon footprint. According to the EPA, each gallon of gasoline burned released 19.4 pounds of carbon dioxide.[73] Therefore, assuming that three shipments come in every day of the year, this adds another 160 tons of carbon dioxide to the atmosphere each year.

Based on the amount of carbon dioxide released each year, the next step is to look at how much carbon is sequestered carbon by the forests from which the biomass is taken. This approach is problematic for a number of reasons. First, it is still not clear exactly which forests the biomass is coming from. Therefore, we do not know these forests' ability to sequestration carbon from the atmosphere. Secondly, there is also a time element in dealing with sequestering carbon. Biomass carbon dioxide is sequestered on a biological scale, rather than the geologic time scale that is the case for fossil fuels, which will not be replaced for millions of years. However, in order to calculate how long it takes to sequester the carbon associated with Middlebury's biomass burning, it would be necessary to continue to monitor the logging jobs over a period of years following the initial cut in order to monitor the re-growth progress of the forest. The third main issue is that there have been a number of different studies performed on the ability of forests to sequester carbon, but these numbers differ widely based on climate, season, type of cut, and soil type. As Professor Marc Lapin mentioned in an interview, many of the rigorous studies that have been done on carbon recapture look at the forests of New England as a whole, and it would be extremely difficult and error-prone to attempt to apply these calculations to single parcels of land where the Middlebury biomass is derived. One such study was done on a study plot at the Harvard Forest. However, this study revealed calculations for sequestration in a forest that is *not* currently being harvested.[74] Therefore, for our purposes, it would require further study of the effects of logging on the ability of forests to sequester carbon, especially because the trees that sequester carbon the most rapidly are the youngest trees. The years immediately after the cut are the most crucial.

It is recommended that Middlebury College begin accounting for the carbon released as a result of its biomass facility, from harvesting to burning, and also look into further study about the ability of the surrounding forests to absorb carbon before concluding that the biomass is indeed carbon neutral.

The analysis above has focused on traditional logging as a means of biomass procurement for the College since this is the current situation. In the future, however, we recognize that the College may choose to pursue alternative sources for its biomass. Under this scenario, it is important that the College expand upon both its procurement standards and monitoring procedures to ensure that all biomass sources reflect commitment to Middlebury's sustainability goals.

VII. Alternatives to Current Supply

The future of biomass in Vermont is unpredictable. Middlebury's role as a center of education and innovation provides opportunities to develop alternative solutions for meeting our biomass needs. These could decrease the College's impact on surrounding forests, stimulate the local economy by introducing new products, diversify our current sourcing options, and provide significant educational and community benefits. The next section of the report outlines the potential of using alternative sources of biomass (willow, mill residue, and stump dump wood) to fuel Middlebury's plant, outlines possible College partnerships with outside players, proposes alternative management scenarios, and concludes by emphasizing the importance of reducing heat demand as a fundamental component of the College's energy plan.

Willows

Efforts to increase the reliability, diversity, and value of Middlebury's woodchip supply led the College to look into the potential of growing willow shrubs on agricultural land to provide a portion of its biomass. In 2007, before the construction of Middlebury's biomass gasification plant, the College entered into an agreement with the State University of New York College of Environmental Science and Forestry (SUNY-ESF) to develop a willow test plot of nine acres of College land. Depending on the success of the experimental plots, the College potentially aims to begin preparations for major willow planting in 2011. Middlebury College needs to be especially careful when moving forward with willows because of the many uncertainties surrounding their economic viability and environmental and social impacts. The following section outlines the multiple considerations the College will need to address if it decides to further pursue willows on a large scale.

Land Availability

One of the first steps in large-scale willow production is to identify land that is suitable for willow development. The College's biomass gasification plant consumes approximately 20,000 tons of woodchips per year, replacing 1 million gallons of #6 fuel oil.[75] Under one possible scenario, the College would aim to source half of its woodchip demand from willows, or about 10,000 tons per year. According to a SUNY-ESF study on the estimated biological productivity of willows, 400 acres of willows should produce approximately 10,000 dry tons of woodchips at harvest time. Because willows do not reach harvest maturity until the end of their third year of growth, the school would need to plant 400 acres each year for three consecutive years, totaling 1,200 acres, in order to maintain a constant yearly supply of woodchips.[76]

Willows are a resilient crop that can grow practically anywhere.[77] For the College's purposes, willows must be grown on tillable land so that a modified corn harvester can harvest and chip them. The region around Middlebury has a plentiful supply of tillable land, however, most of the land is already intensively used for dairy, corn and hay.[78] Unused agricultural land could also be converted to willows, but this would remove shrub land habitat.[79] The College should proceed carefully to ensure that

any willow project does not place an undue burden on the state's dairy industry. Some struggling dairy farmers might find supplemental income from the project if they were to partake in growing willows, but it is also important to be aware of the implications surrounding the conversion of land from a food source into an energy source.

College Land

The College currently leases agricultural land to local farmers that could potentially be converted to willow production. The College owns approximately 1,350 acres of crop/hay fields and approximately 400 acres of pasture, which are currently leased.[80] According to Tom Corbin, the College's Assistant Treasurer, the land is being used to grow hay and corn for feed on the lessees' dairy farms.[81] These hay and crop fields would be suitable for growing willows, and further studies could determine whether some of the pasture might be converted as well. There are three primary sites on College land where willows could be grown (Figures 9-12). These three sites contain the vast majority of the College's tillable fields and pasture. These maps are a reference and are not meant to suggest exactly where willows should be planted. As the figures show, wetlands could be an issue at all three College-owned sites, and buffers would need to be instituted to mitigate pesticide and herbicide runoff.

If the College were to use its own land to grow willows, the school would first have to let its current lease contracts expire. Next, the College would either have to establish new agreements contracting farmers to grow willows, or employ an individual or group within the College community to produce the willows for wood chips. No lease continues past May 2013, and by the time the first willows would need to be planted in the spring of 2011 several leases will have already expired. The leasing of College land was originally done to receive significant tax breaks because the land was otherwise sitting unused.[82] Conversion from feed to willow production would likely preserve these tax breaks, but must be considered carefully before proceeding forward. Middlebury's agricultural lands are relatively wet and marginal in quality so lessees might be more willing to leave, especially with adequate forewarning.[83] If the College were to pursue willow production on College-owned land, it should focus on converting the land that is least valuable as supplementary cropland. The effects of converting cropland to willow production are unknown, but the College should understand the local and global implications of converting land from food to fuel production.

There are many potential benefits to growing willows on College-owned land. The College would gain more direct control over the production of a portion of the school's woodchip supply, as well as a reduction in production costs since purchasing land or establishing contracts with other landowners would not be necessary. By using its own land, the College has more control over maintaining important ecological standards. Middlebury has a great understanding of its own lands, so the College would be able to establish and maintain landscape planning principles that would be much more challenging to achieve in contracts with private landowners. Also, using nearby College-owned land minimizes the environmental and economic costs associated with biomass transportation. Finally, College-owned land would create important connections between the campus community and its heating source. The willows could provide educational opportunities for class field trips or tours during new student orientation. Each of the sites are located only a short bike ride away from campus.

While the College has enough land to meet its goal of growing 1,200 acres of willows, this would involve converting nearly all of its agricultural land into a willow crop. This is unlikely to be attainable and centralizing so much of Middlebury's biomass supply in such a small area is not necessarily desirable. Therefore, to ensure diversity of supply within willow production, the use of private land for willows should supplement that of the College.

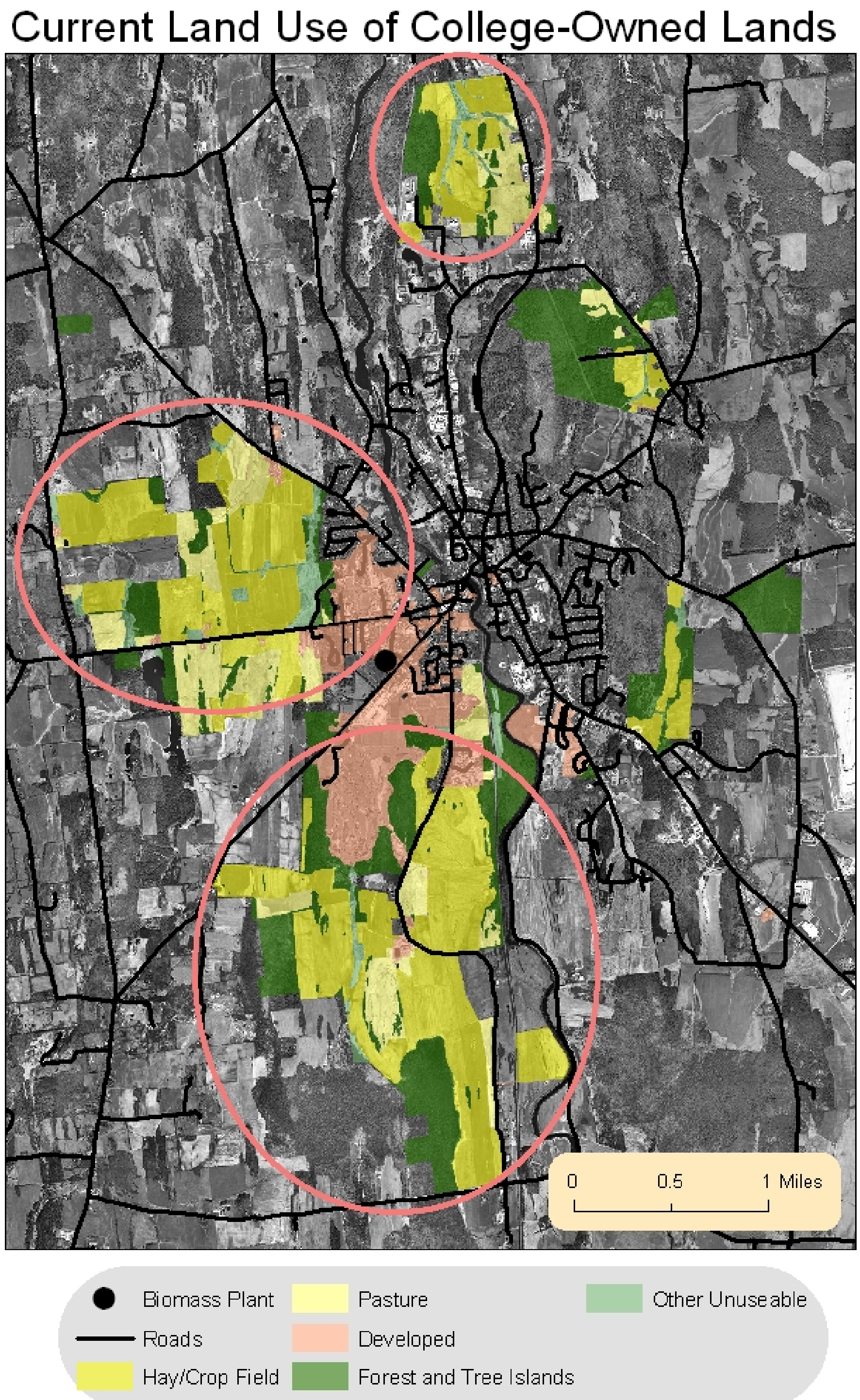

Figure 9: College lands where willows could be grown. The three sites each boast hundreds of acres of arable land and pasture that could be potentially converted to willow.

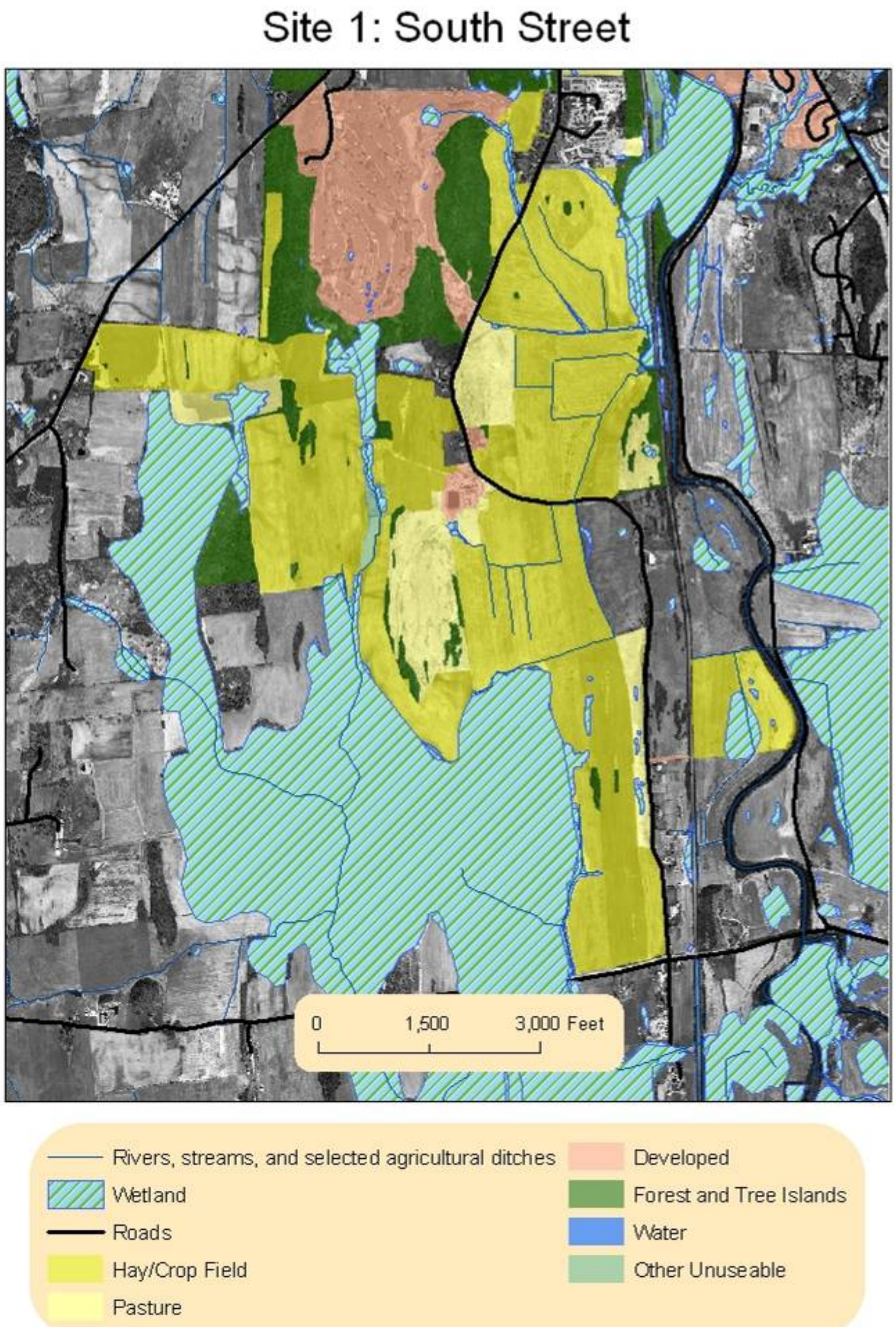

Figure 10: The largest College-owned site is located south of Porter Hospital along South Street. Note the presence of a large swamp nearby. This site includes 600 acres of hay/crop field and 100 acres of pasture under College ownership.

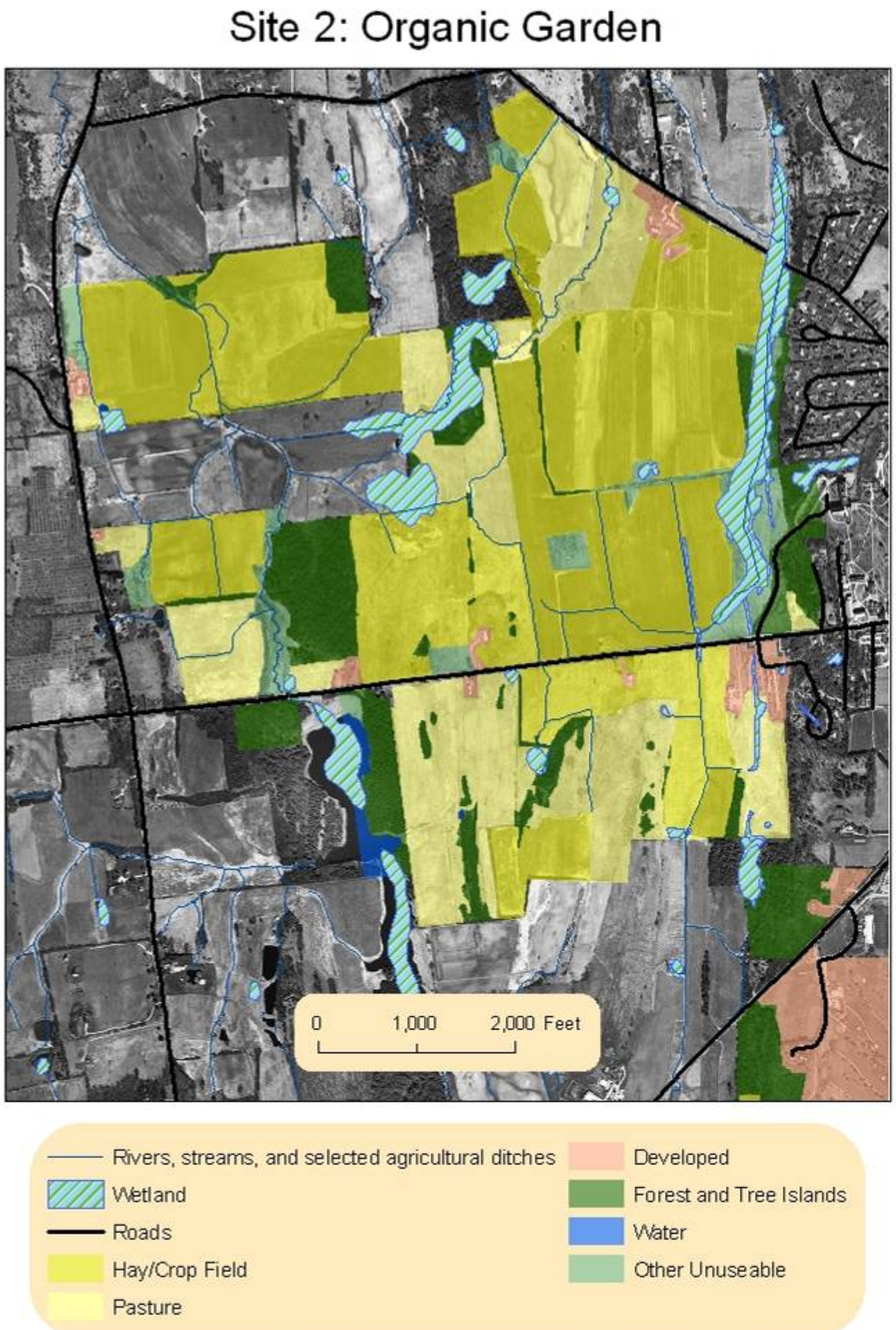

Figure 11: The College also owns approximately 425 acres of hay/crop fields and 170 acres of pasture west of campus surrounding the organic garden. Buffering of wetlands will likely be necessary if this site is converted to willows.

Site 3: Route 7 North

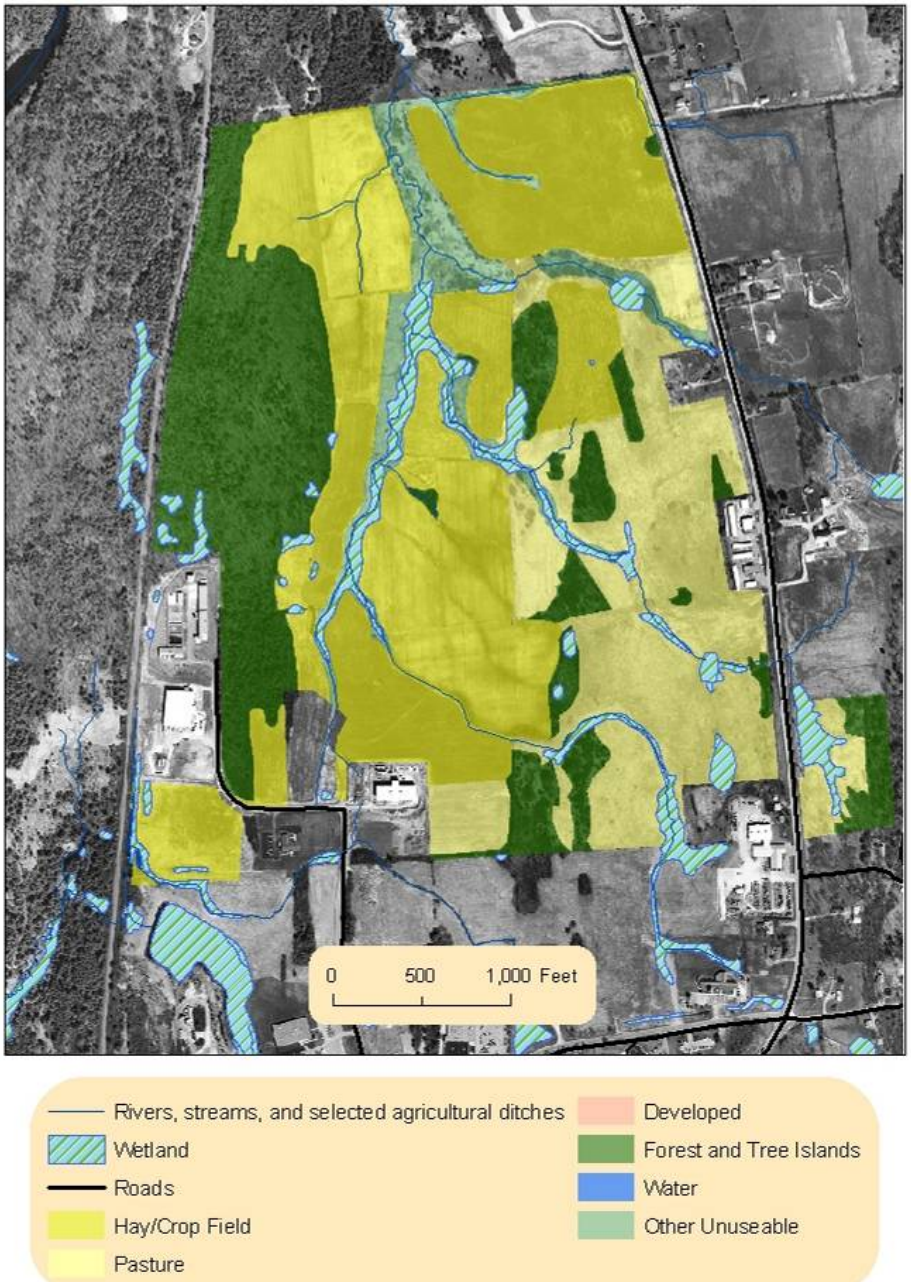

Figure 12: The College could also develop a willow plantation on 120 acres of hay/crop fields and 70 acres of pasture located north on Route 7, close to Paquette Self Storage and Monroe Street Books. Like at the other two sites, site preparation would also need to take into account adjacent wetlands.

Private Land

Local private landowners could be hired to grow willows for the College. Recent coverage in the local and national press of Middlebury's willow project has garnered the attention of several potential willow farmers in Addison County and the surrounding region. Tom Corbin has noted that every time Middlebury's biomass plant is in the news, he receives eight to ten phone calls from private landowners offering to grow willows for the College on their lands.[84] In part due to the current economic crisis, individual landowners throughout the area are increasingly looking for ways to turn a profit from their land. Because willows are an extremely low-maintenance crop and not as ecologically taxing on the land as corn, growing willows with which to supply Middlebury College's biomass is an attractive option for many local landowners.

There are numerous concerns with contracting out private landowners to grow willows, and several issues would need to be fully addressed before any planting occurs. In employing several different landowners to grow willows, the College would lose direct control over its woodchip supply and would face increased monitoring, administrative, and processing costs due to the complexities associated with working with several different suppliers. Nonetheless, there are benefits to a decentralized scheme. Willow plots scattered throughout the region would help to decrease the vulnerability of the woodchip supply and pose less concentrated changes to the landscape. The marketing of willows throughout the region would stimulate the local economy. Furthermore, if the College were to plant willows on private land rather than its own land, the current leases with farmers would not need to be terminated, and the school would continue to reap the tax benefits of those leases.

Despite these benefits, growing willows on non-College land comes with significant additional costs, most notably land. If the College already owns 1,200 acres of suitable land on which it could grow willows, it is hard to justify paying for the use of outside land in addition to production costs. The school would also need to work out the details of contracts with willow growers and address each of the following concerns:

1) Expectations for ecological standards – the College would need to make clear to the farmers its expectations of the standards of willow production and ensure they are comparable to the standards outlined in the beginning sections of this report.
2) Payment schemes to the farmers – because woodchips would not actually be produced until the end of the fourth year after site preparation begins, the school and farmers would need to agree on how much and how often the farmers are paid in the meantime. The contract would also need to address payment in the event of crop failure.
3) Contract exclusivity – the contract would need to ensure that the woodchips grown by the private landowners are strictly for the College's consumption and cannot be sold to other buyers at a higher price.
4) General payment – the payment agreement would need to establish the price per ton paid to the farmers with consideration of who is responsible for paying the substantial upfront costs of planting, as well as decisions regarding cooperative harvesting and transportation schemes among individual farmers.

The College should also take into consideration that landowners are unfamiliar with willow production, and it may be challenging to convince farmers to make the commitment to convert their land. Many—instead of investing in a relatively unknown crop for a second party like Middlebury—might rather use their land for corn and hay for their own cattle.[85] Furthermore, a greater portion of the economic risk of the land conversion and start-up costs would be taken on by the private landowner rather than the College.

Under the private landowner scenario, financial considerations would be the most important issue to address, because the cost-effectiveness of this scenario will necessarily be its determining factor. The economics of willow production are extremely complex and subject to numerous unknown factors that could significantly alter costs to the College. Minimizing those costs is vital to the feasibility of the project.

Economic Considerations

Baseline estimates for the economics of willow production for Middlebury College are obtained using the 2008 EcoWillow v1.1 (Beta) economic model designed by SUNY-ESF.[86] The following calculations are modeled for the lifetime production of a 400-acre plot of willows. It is important to keep in mind, however, that actual costs may vary significantly. The situation that will unfold over the course of the next 30 years, and especially the next three years, will remain unclear at least until the results of the test plot are known. Furthermore, not only are logistical realities unclear at the moment, but there are also factual discrepancies within the biomass industry about estimated costs of willow production. These discrepancies greatly alter the modeled costs of production and are noted below where necessary. As it stands, the test plot willows will not be harvested until the winter of 2010-2011. Depending on the results of that harvest, the first 400-acre plot will not be planted until the following spring of 2012.[87] Currently, the only available status reports on the College's test plot focuses on the ecological impacts of the willows, i.e. soil and water quality, though the SUNY-ESF researchers partnering with the College have indicated that the willows are growing better than expected.[88] Nevertheless, it remains to be seen if Middlebury's biomass gasification facility can adequately process and obtain an acceptable BTU value from woodchips derived from willows in the first place. Assuming willow woodchips function well in the gasification equipment, several factors may still not be completely resolved for the next three to four years. The following sections outline many of these factors and provide concrete data on them where possible.

Establishment Costs

According to the EcoWillow model, the total costs of preparing the land and planting 400 acres of willows are estimated to be approximately $1,096 per acre. This value is highly comprehensive and calculates for considerations such as fuel and labor. The value for total establishment costs is relatively stable and does not vary depending on land ownership. Under either scenario – growing on College land or private land – the establishment costs would be the same, though who pays them would depend on the contract with private landowners. Estimating harvesting and transportation costs is more difficult due to several unknown factors regarding woodchip drying, harvest methods, and discrepancies regarding rates of harvest.

Harvesting Costs and Considerations

For ecological and economic reasons, the willows would be harvested and chipped for consumption during the winter months (November – March). As discussed below in the section on ecological considerations, the willows would be harvested after all their leaves have fallen, sometime in late fall. On the economic side, woodchip prices in Vermont are highest during the winter months as other players in the woodchip market increase their demand. Public schools across the state also burn woodchips to heat their facilities during the winter. It would be economically efficient to consume all of the College-grown willow woodchips during this period of time instead of paying higher prices for woodchips from outside sources. Under these circumstances, though, if the willows are harvested in the winter months it remains to be seen if the wood, which is chipped and harvested by the special harvester head, would first need to be dried, since it may be covered in snow, before it can be processed in the school's gasification plant. This information should be known with the results of the test plot. It should be noted, however, that woodchips delivered by Cousineau harvested in snow-covered forests do not undergo any additional non-natural drying processes before they are burned.[89] It is also important to note that if willow woodchips do require additional drying before they are processed, willow production will no longer be a viable option due to the significant energy costs required for drying.

Harvesting Costs

The costs of harvesting willows are highly dependent on the rate at which willows can be harvested, which is in turn greatly influenced by the scale of the operation. According to the EcoWillow model, 400 acres worth of willows can be harvested at 2.2 acres per hour (55 wet tons per hour) for a total harvest time of 180 hours. This comes to a total harvesting cost of $230 per acre, which again is a highly comprehensive value accounting for labor, rental rates, and fuel use of a harvester and trailer-tractors. At this rate and an 8-hour workday, harvesting could be complete in 22.5 days. If the school opts to complete harvesting in the first 22.5 days of the harvesting season, it would be faced with the additional challenge and costs of storing the woodchips and transporting 120 tons of chips to the biomass facility each day. Below is a brief discussion of the challenges and costs associated with willow woodchip storage.

Storage Costs and Considerations

Unless dried through non-natural processes, woodchip piles can heat up to 140°F within a few weeks and are not suitable for long-term storage. Risks of spontaneous combustion and accelerated decomposition accompany improper management of chip piles. However, even when maintained in ideal pile sizes to mitigate these risks, thus increasing the amount of land necessary for storage, three to four months is still the maximum storage duration for green chips.[90] Because woodchips derived from willows contain a greater ratio of leaves and bark to wood pulp than standard woodchips, willow chips have an even shorter shelf life. Nevertheless, a 1979 report by the USDA Forest Service suggests that covering piles of dried whole-tree chips (i.e. chips that have not been cleaned and debarked) with a polyethylene film is still a cost-effective method to preserve woodchips for an extended period of time.[91] The report indicates that the price of the polyethylene film to cover the woodchip pile averages out to approximately $4.00

per ton (in 1979). Using this number for lack of more accurate data and accounting for inflation, the cost of the film would be a conservative $12.00 per ton in 2015. The report also cites a 1962 study by Ritcey on the costs of moving chips into and out of storage piles: about $0.50 per ton. Allowing for increases in efficiency and upward adjustments for inflation, the handling costs of stored chips would be at least $4.50 per ton in 2015. To harvest and store all 10,000 tons of willow woodchips, the College would face a roughly estimated total cost of $204,668, or $20.50 per ton, each harvest year.

This value still does not account for the costs of transporting the woodchips between the harvesting site, the storage, and the biomass facility. While that value cannot be determined at the moment, the costs would surely be considerable. It is because of these high costs associated with storage that it is recommended that the College does not harvest all 400 acres of willows in the first few days of the winter season. Instead, it is recommended that no more than 150 tons of woodchips – the maximum volume that the storage bunker attached to the biomass facility can hold – are harvested each day. It should be noted, however, that while additional storage and transportation costs would no longer apply to an on-demand harvest schedule, decreases in harvesting efficiency may occur if workers only harvest for a few hours a day. This could result in a modest increase in harvesting costs, however those values cannot be modeled; rather they will be determined in practice. Possible harvesting schedules are discussed below.

Harvest Schedules

At a harvest rate of 150 tons per day and a consumption rate of 120 tons per day, one additional day's worth of woodchips is accumulated in storage at the end of four days of harvesting. Therefore, harvesters could work for 2.2 hours each day for four days in a row and rest on the fifth day. Table 7 shows the calculations for the recommended harvest schedule.

Harvest Day	Total amount harvested at end of each day at rate of 150 tons/day (tons)	Total amount consumed at end of each 24-hour period (tons)	Total residual amount in storage bunker (tons)
1	150	120	30
2	300	240	60
3	450	360	90
4	600	480	120
5	0	600	0
*Note: 120 tons per day consumed			

Table 7: Potential Harvest Schedule for a 4-day cycle.

Transportation Costs

The EcoWillow model again provides the estimated costs associated with transporting woodchips from the harvest site to the processing site. Estimated transportation costs total $28 per acre. 3.5 miles is used as the average distance between harvesting sites and the biomass plant at the college. The average mileage value was estimated from the above maps showing the geographical distribution of College-owned

lands, on which the willows would be grown, in relation to the location of the biomass facility. Again the $28 per acre value includes rental rates, fuel consumption, labor, etc.

Stump and Root Removal Costs

After the tenth harvest of the willows, the maximum lifespan of a single planting for biofuel purposes, the stumps and roots will need to be removed. The SUNY-ESF model estimates this cost to be $300 per acre.

Total Costs

Based on data from the SUNY-ESF willow model, total estimate lifetime costs per ton of willow woodchips is approximately $15 per ton for the estimated 10,000 tons a year for 33 years (Table 8). This value is in 2008$ and does not account for inflation. Inflation was not accounted for because the value is meant to be a comparison to the price per ton of woodchips that the College currently pays through its contract with Cousineau. Both price values will likely increase due to inflation over the course of the lifetime of the biomass plant. The $15 per ton value applies to willow production on College-owned land and the on-demand harvest schedule.

If the school were interested in meeting only one quarter of its biomass supply through willow woodchips, total lifetime costs would be approximately $15 per ton for the estimated 5,000 tons a year for 33 years.

As noted in the introduction section of economic considerations of willows, factual discrepancies about estimated costs of willow production exist within the biomass industry. These discrepancies have significant implications for the total costs of willow production. According to Adam Sherman, program director of Vermont's Biomass Energy Resource Center, the harvest rate of willows can range from 0.4 to 1.2 acres per hour, or 10 to 30 dry tons per hour, using an adapted corn harvester. On the other hand, a 2000 study by Oak Ridge National Laboratory for the US Department of Energy provides data for a commonly employed harvester: the Class Jaguar.[92] The report states that the Jaguar requires 1.5 hours to harvest one acre (0.63 acres per hour) and can produce 9.43 dry tons per hour. The SUNY-ESF model calculates for a harvest rate of 2.2 acres, or 55 tons, per hour. The variation between these three harvest rates results in a range of total harvest time for the 400 acres of 22.5 to 133 days. At a rate of 133 days or 1,060 hours to complete the harvest, harvest costs rise to $1,349 per acre (compared to $230 per acre as previously modeled). Such a slow harvest rate would bring total lifetime costs of willow production to around $61 per ton. These discrepancies illustrate how actual costs of willow production may vary significantly in practice, despite the numbers modeled. While the SUNY-ESF model is believed to provide the most up-to-date and accurate data, willow production is new and site specific. It is therefore crucial that the College proceed with caution and undertake willow production at a pace and scale that allows for trial and error.

Year	Total costs of 10,000 tons using SUNY-ESF modeled harvest rate	Total costs of 5,000 tons using SUNY-ESF modeled harvest rate	Total costs of 10,000 tons using USDOE harvest rate
2012	$438,400	$219,400	$438,400
2013	438400	219400	438400
2014	438400	219400	438400
2015	103200	52000	550800
2016	103200	52000	550800
2017	103200	52000	550800
2018	103200	52000	550800
2019	103200	52000	550800
2020	103200	52000	550800
2021	103200	52000	550800
2022	103200	52000	550800
2023	103200	52000	550800
2024	103200	52000	550800
2025	103200	52000	550800
2026	103200	52000	550800
2027	103200	52000	550800
2028	103200	52000	550800
2029	103200	52000	550800
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2038	103200	52000	550800
2039	103200	52000	550800
2040	103200	52000	550800
2041	103200	52000	550800
2042	103200	52000	550800
2043	103200	52000	550800
2044	103200	52000	550800
2045	103200	52000	550800
2046	103200	52000	550800
2047	223200	112000	670800
Total Cost	$4,840,800	$2,434,200	$19,611,600
Average Cost per ton	$14.67	$14.76	$61.29

Table 8: Estimated Lifetime Costs of Willow Production on College-Owned Land

Ecological Considerations

If the College chooses to establish a large-scale willow plantation, many ecological considerations will have to be taken into account. Much research has been undertaken to help establish guidelines for the responsible management of willows. A College report published in 2007 provides an extensive review of the major findings of research on willows.[93] Middlebury would benefit in following high standards for willow plantations in several ways—the College would improve the sustainability of its sources of biomass, boost its environmental image, and provide a responsible willow growing model that others could follow. On the other hand, Middlebury will need to carefully evaluate the costs of higher standards, since the current economic models for willows minimize some ecological considerations and consider the most cost-effective ways of growing willow.

Willows are an ecologically attractive method of growing biomass for several reasons. Harvesting is generally undertaken in winter when disruption of animal habitat is minimal, soils are frozen and protected from erosion, and leaves have already fallen and cycled nutrients back into the soil.[94] While diseases and pests can severely affect willow plantations, research has found little negative impacts in the northeastern United States, and Middlebury's test plot has experienced few problems.[95] Browsing mammals and some insects can disrupt the establishment of a willow crop, while insects and fungal pathogens are the main problem for the matured crop.[96] A relatively high level of leaf damage can be tolerated by willows, but severe or repeated attacks will reduce yield and extreme cases may cause crop death. Using a large mixture of varieties is the best way to mitigate the impact of pests and diseases.[97] Good site preparation can help further reduce the risks.

Many of the most environmentally sensitive aspects of willow relate to its planting and establishment. The most important ecological factor to consider when establishing a willow plantation is the prior use of the land that would be converted. Research has shown that willow cultivation generally has a less damaging impact on the land than land that is being managed for row crops and has an impact comparable to that of lands managed for hay.[98] Life cycle assessments of willows have generally been favorable. Studies have shown that conversion of land from row crops to willow significantly improves the capacity of that land to sequester carbon, although initial carbon losses are likely.[99] Conversion of hayfields and pasture to willow—the most likely scenario if Middlebury were to pursue willow—typically results in "no net long-term change in the soil carbon pool, although initial releases of soil carbon into the atmosphere should be expected."[100] The conversion of abandoned, overgrown agricultural lands to willow stands creates negative impacts because the land provides native species habitats and converting it would create a net loss of carbon.

The conventional conversion of agricultural fields to willow takes place over the course of one year by spraying pesticides and clearing the land in the fall and planting the following spring. The disadvantages of the conventional system are that it generally involves heavy use of herbicides, puts the soil at greater risk of erosion, and expands the time frame needed to sequester carbon losses.[101] Alternative methods have been developed to reduce these negative impacts of conversion.[102] These methods would take longer (2-3 years) but would use cover crops instead of herbicides to combat weeds and reduce soil erosion, and the willow shrub would be planted into the cover crop.

The weather may limit when willow planting can occur, and the College would need to build flexibility into its willow plan as there may be some years when the soils are too wet for planting.[103] Furthermore, negative impacts to water quality may result from erosion and runoff of chemical herbicides and pesticides associated with the crop.[104] Buffering willow plantations from sensitive wetlands and reducing chemical inputs can help mitigate these impacts.

It is important that the College establish standards for how it might go about growing willows, just as it is establishing procurement standards for its biomass harvested from forests. The standards should take into account—but not be limited to—the following issues:

- Site's prior land use;
- Site preparation;
- Conventional versus multi-year/cover crop;
- Pesticide and herbicide use;
- Diversity of willow crop;
- Riparian buffers;
- Erosion potential;
- When to harvest (season, weather).

Aesthetic Impact of Willows

Another factor that has been relatively unexplored is the impact willows would have on the aesthetic landscape of Champlain Valley. If 1200 acres of willows were to be planted in Addison County, how would that change the landscape of the region? If Middlebury's willow project convinces other players, such as the Town of Middlebury, to follow our lead, is there a limit to how many acres of willows throughout the landscape are acceptable? The College might consider researching these and other questions in the future.

Educational Opportunities of Willows

Depending on the proximity and visibility of willows to campus, classes could take place in the willow plantation and College groups could use the site as a destination for field trips. Students could use the willow plantation as an opportunity to undertake research projects. Proximity and visibility to campus will also provide a constant reminder to campus users of the natural impact of our heating and energy demands. Overall, willow plantations could provide many promising educational opportunities. Future work should look to identify more ways in which willows could contribute to the College academic mission.

Conclusion

While harvesting willows as one of our main sources of biomass would help the College mitigate many of the challenges associated with harvesting biomass from the region’s forests, willows nevertheless come with their own economic, ecological, and social complexities. There are ways to grow willows that are economically feasible and have a minimal impact on the environment and other land uses, but it is recommended that the College fully address the majority of the considerations outlined above before it begins large-scale production of willows and proceeds with production at a gradual rate.

Stump Dump

The Middlebury College Biomass Report states that approximately 600 tons of wood per year are left at the Town of Middlebury's stump dump.[105] Small property owners and landscape businesses pay to drop off the unwanted wood, where it is chipped and usually left to decay. Due to the limited volume, stump dumps would not provide significant amounts of chips, but since it is already chipped, it would likely be practical to incorporate some amounts of stump dump material. The McNeill power station in Burlington currently uses stump dump material in its plant.[106] Little is known about the quality of the wood coming from the stump dump in Addison County, and it remains to be seen whether these chips could even be used in the College's biomass plant.

Mill Residue

Sawmills may provide a supplementary source of chipped biomass. If available, mill residue would be convenient because the biomass would have already been chipped. Additionally, consuming biomass chips produced as a byproduct of timber production circumvents direct impact on forest ecosystems. However, the availability of residue for Middlebury College when considering socioeconomic impacts of demand and the logistics and cost of acquiring chips from multiple small sources pose considerable barriers.

While a substantial quantity of mill residue is being generated in Vermont, demand for mill residue currently matches this supply. According to the Vermont Department of Forests, Parks, and Recreation, 192,563 green tons of mill residue was produced in 2006, of which 133,365 green tons were fuel chips.[107]

	2006	2005	2004	2003	2002
Mill Residues (gt)	**192,563**	**208,879**	**216,128**	**184,986**	**237,941**
Pulp	59,198	119,885	130,075	94,748	80,286
Fuel	133,365	88,994	86,053	90,238	157,655

Table 9: Vermont Forest Resource Harvest Summary

Sawmills in the two counties of Addison and Rutland produce and sell 26,000 tons of mill residue each year.[108] Out of a sample of four mills from a list of potential wood chip fuel suppliers, none currently generate waste that is not sold or consumed in some way.

The sample of mills contacted share a seasonal model of mill residue flow. Currently, Cersosimo Lumber Co., Gagnon Lumber, Inc., and A. Johnson Co. annually generate about 40 to 50 tons, 3,000 tons, and 10,000 to 14,000 tons of residue, respectively. [109] Approximately half this amount is consumed by high schools for heat, and the other half used as pulp for making paper products.[110] Accounts of biomass consumption vary depending on the source. While the Biomass Energy Resource Center uses a figure of 36,000 tons a year (Table 3), the College has been using the figure of 41

schools consuming 19,000 tons a year. [111, 112] These schools rely on high-quality fuel chips from mills for winter heating between September and April.[113] During warmer months, the International Paper Company's Ticonderoga Mill is a major buyer of softwood pulp chips from all contacted mills. Other sources of demand for mill residue include Burlington Electric and pellet companies such as New England Wood Pellets.[114] Additionally, Cersosimo Lumber burns 50% of generated residue on-site to power its dry kilns.[115] A. Johnson Co is a current supplier of mill residue to Middlebury College in the summer months through our broker.

A general trend of increasing demand for fuel chips in winter has led some of the sawmills to consider the acquisition of a chip mill in addition to their current infrastructure. Both Brattleboro town and the Veteran's Administration Medical Center in White River Junction have approached Cersosimo for its residue as they consider woodchip-based heat and power programs. To address such demands, Cersosimo Lumber Company is currently looking into constructing a Biomass Crop Assistance Program (BCAP) certified chip mill that would be operational beginning October 2010 and would generate an additional 50,000 to 75,000 tons of chips available for sale to the open market.[116] Gagnon Lumber, Inc. is also considering the acquisition of a separate chipping unit for biomass.[117] The supply would come from low grade wood that Gagnon does not currently accept but that is already harvested for pulp and firewood.

The acquisition of an additional mill for the sole purpose of supplying biomass chips implies that biomass chips are on their way to transitioning from a byproduct of other forestry industries into a commodity in itself. This has economic and ecologic implications that the College must consider. As a byproduct, wood-chip biomass extraction does not exert significant additional pressure on forest ecosystems. If wood-chips were to become a freestanding commodity, forest biomass extraction would likely increase and impact forest ecosystems. Alternatively, in the case of Gagnon Lumber, the wood would be channeled away from the pulp and firewood industry, which could have socioeconomic implications on Vermonters who depend on firewood to heat their home cheaply and sustainably. [118] It could also result in a net increase of biomass extracted from forests.[119] In other cases, increased supply of biomass chips from sawmills would raise questions of how sustainable harvesting could be promoted, and makes the College's adoption of biomass procurement standards even more relevant and important.

The increased interest in biomass chips is also a product of macroeconomic and industrial changes. As rates of housing construction fell, the use of high-quality, furniture wood decreased and downgraded from manufacturing to chipping. This increased demand for low-grade wood, and now suppliers are increasingly extracting low-grade wood that was previously left in the forest.[120]

Prices of chips on the market experience large fluctuations, shifts that our established contract with Cousineau helps to buffer. The current market price for Cerosimo Lumber's chips are $45 per ton when the buyer picks them up. Delivery with a self-unloading trailer is an additional $20 per ton, with a sum of $65 per ton. [121] At Gagnon Lumber, Inc., softwood pulp chips are delivered to the dumping station at International Paper which requires no specialized trailer at $30 per ton. Similarly, hardwood chips are $40 per ton. Fuel chips during the winter season are $60 per ton because delivery of these chips to high schools requires the use of a self-unloading trailer.

Though operational costs are not exceptional, replacement costs for self-unloading trailers are 5-10 times that of standard trailers and necessitate this additional fee.[122]

While all mills contacted were within 75 miles of the College, the source of their lumber varied. Cerosimo Lumber in Brattleboro is an aggregator receiving lumber from vendors all over the northeast.[123] Fortin Transport, located in Derby, sources its wood from mills in Canada.[124] 20-25% (600-750 tons) of wood processed by Gagnon Lumber is FSC certified, but the residue from this wood is not distinguished from other residue, so it would be impossible to know the harvesting standards of the biomass.[125] These residues will be generated within the 75 mile radius, but the College must decide whether or not to accept mill residue, given the dispersion of the original source and unknown harvesting practices.

In general, contacts at four sawmills expressed interest in supplying Middlebury with biomass. Fortin Transport indicated the likely possibility of delivering four 25 ton loads each week for the College.[126] Gagnon Lumber indicated an interest in Middlebury due to its proximity, which is half the distance of its current delivery route to International Paper Co.[127] Cersosimo Lumber also commented that there should be a supply accessible to Middlebury beyond October 2010, and A. Johnson is already a sub-contractor to the College through the current broker. [128] However, our priority considerations of not competing with or removing current buyers from the supply chain may prevent us from purchasing biomass from sawmills that local schools depend upon. Projected prices largely fail to compete with the College's current contract, but they may be a surmountable barrier. $40 for hardwood chips is only $1.50 more than our current contract price which yields an 8.43% IRR on the biomass plant initial investment. The upper extreme of $65 per ton (of $45 per ton with $20 per ton for delivery) would be within the range of a 5% IRR if oil prices top $1.75/gallon as it did in 2008.

In conclusion, mill residue supply is an economically feasible source of biomass chips. However, serious barriers include its limited availability and ensuring compliance with the College principles of sustainability and social responsibility. Mill residue as a byproduct is currently being consumed already, and chips as a commodity necessitate the use of standards and compliance monitoring as with our current broker.

College-Owned Aggregation Station

We investigated the potential for a College-owned aggregation station for lumber from small-landowners. A simple storage facility near the recycling center or compost facility on campus would hold biomass in tree-length form. Alternatively, the station could be placed in Ripton, in close proximity to the College's forested lands. The station would be run by College a College employee. Depending on the scale of the operation, the position may be part-time, part of existing positions, or full-time. This would open our market to small land-owners and provide a very local supply option. While uncertainties remain, the College would have to devote significant energy into developing the details of this operation.

Benefits of such a facility would be manifold. First, such a station would increase the reliability and diversity of the College's biomass sources by making it easier for small, local landowners to enter Middlebury's biomass market. Second, it would enable Middlebury College a greater degree of independence by taking a portion of the

control out of the hands of the broker. Third, in the case of a greater preference for biomass from larger landowners under the current broker contract, this venue would open up the supply chain to those landowners whose lands are too small to accommodate or financially legitimize the use of chippers on their land. Fourth, tree-length storage not only eliminates the risk of combustion but also lowers the moisture content of the logs. Finally, an aggregation station in Ripton would facilitate the processing of biomass from the College's own lands and provide a location for chipping.

Site requirements for such a station are variable but are likely surmountable given the College's lands. For example, setting up an aggregation center on pasture land would require sufficient gravel to create a path fit for heavy trucks in wet weather as well as consideration of factors such as slope, drainage, and durability and suitability of path surfaces. [129] A reasonable capacity for the purpose of receiving wood from small landowners and procuring a back up supply would be within a range of 1250 gt to 1890 gt of biomass in log form, which would be 2 to 3 weeks of the College's uppermost extreme of the peak consumption range of 60 to 90gt/day. [130]

More substantially, the costs of setting up a station would vary depending on the site upon which it is to be built and on the quality of infrastructure and equipment. First of all, loading and unloading the trucks may necessitate a log loader device and a truck scale. A log loader device would be necessary unless the delivery trucks are self-unloading and have their own crane. A wheeled log loader device with a hydraulic lift would be a couple of hundred thousand dollars. Used machines may be available for $10,000 to $30,000. [131] Moreover, Vermont's state law mandates that any material with a price by weight be weighed. In the logging industry, truck scales that weigh the difference in the weight of a truck before and after unloading are used for this purpose. This implementation involves a metal deck with sensors that the truck would roll on to, and a new device would cost in the magnitude of a hundred thousand dollars. Used scales would be in the range of $30,000 to $50,000. As more intensive site preparation involving excavation, concrete, and electricity provision would be required to set up a truck scale; such an investment would be hugely underutilized unless the College were to commit to taking over the broker's current role of managing and coordinating all of the biomass it consumes. It would be more advisable for the College to pay a fee of $5 to $10 per weigh to a scale operator that already has this capacity. Apart from operations handling logs, examples of potential contractors that would already have the yard space and necessary equipment for loading and unloading logs on and off of trucks include old gravel pits, concrete manufacturers, and quarries.

Secondly, a chipper and trailer would be necessary for handing the biomass to deliver on demand. Chippers of the horsepower size range most appropriate for a College-owned facility are generally not available for rent. Rather, the College would pay an operation fee of $6 to $10 a ton to a contractor.[132] However, chipping is a loud and dusty operation that can be a nuisance to neighbors. While the hypothetical sites near the recycling center or College compost and on College-owned lands in Ripton have been selected upon consideration of residential areas, it would be advisable nevertheless to heed possible impacts before committing to establishing a facility for on-site chipping. Similarly, self-unloading trailers that would be necessary for the transportation and delivery of chips from the aggregation station to the College plant are operated by contractors. A fee of $10 a ton would be a reasonable estimate with the current market.

Beyond the financial considerations, there are energy and ecological costs of transportation and handling biomass. A storage location near or on campus may eliminate transportation that would have occurred were biomass harvested near Middlebury to be aggregated elsewhere to be delivered through Cousineau. However, an extra site for aggregation may entail extra handling and transportation. This raises questions of not only the financial costs discussed above but the ecological costs (i.e., carbon footprint) of the operations that should be compared to the current model. Overall, whichever alternative, broker system or College storage facility, a more direct route and less need for handling from the source forest to the plant would be preferred with regard to the delivery scenario. An understanding of the current source and provision route of chips is necessary to make this comparison.

In conclusion, setting up a new aggregation station on College lands would be a substantial investment that may be beyond the realm possibility in the near future. Due to the high cost of the infrastructure needed for an aggregation station, the scale of the storage facility initially considered to supplement the broker contract would be too small to be financially efficient. A larger facility to process the College's entire biomass supply would require the commitment to run such an operation and assure the consistency and reliability necessary to procure the supply so integral to the College function. If the College were to consider taking control of the entire biomass supply, delegating the tasks out to existent operators of such facilities may be more feasible.

Alternative Ways of Managing Supply

Thus far relying on a broker (Cousineau) to provide all of our woodchips has proven reliable and met our needs. However, as this project reveals, there is very little transparency to our supply, which poses barriers to ensuring our woodchips meet the standards we have proposed and Middlebury's commitment to environmental initiatives. If the broker cannot adjust to ensure these goals are met, we have outlined several options to gain the flexibility for innovation and to promote more local, direct-control options to biomass procurement.

Direct Contracts with Loggers

The College could assemble a team of loggers. In conversations with local logger Larry Altman, an individual logger can harvest roughly thirty tons of biomass a day. Middlebury College requires approximately 57 tons of biomass each day. The College

would therefore need to secure chips from several loggers on a daily basis. In addition to the team of loggers, the College would need to hire a forester to manage the land, and establish contracts with private landowners and pursue Breadloaf land. This would require significant administrative effort from the College to ensure reliability, but would allow for more transparency and flexibility in choosing suppliers who meet our standards.

Biomass Energy Purchasing Cooperative

There exist opportunities to partner with other local biomass interests in mutually beneficial cooperation. Currently, a green energy cooperative aiming to build collective market power to influence sustainability standards in biomass harvesting is in the planning stages as a collaboration among Middlebury College, Middlebury Town, and Porter Hospital. Such a cooperative, as proposed by the Town of Middlebury in conjunction with the College on September 9, 2009, has the potential to address some of the issues addressed in this paper. This cooperative is focused on solving the supply problem and potentially considering a second partner biomass plant in the town, but at present everything is in the early planning stages and there are no concrete goals.[133] Figure 13 outlines what consumption curves of a possible second or third plant scenario would look like. The Middlebury Assistant Town Manager, Joe Colangelo, expressed that there is a considerable amount of interest in the project. He finds the prospect of a new plant to be exciting because it blends a community development project that would improve the local economy with a plan to become more environmentally sustainable. After more extensive research, the plan to build one plant that serves several entities was dropped because it would have been extremely expensive to develop a piping system between far-flung buildings. Instead, the biomass purchasing cooperative is the current focal point of efforts. This cooperative is in the initial phases with the help of Jack Byrne, Tom Corbin, Mike Moser, Robin Scheu, and Joe Colangelo. Over the next year, a feasibility study will be conducted to: identify groups in the area that could potentially develop biomass facilities, define the ecological capacity of supply within a 75 mile radius, measure the implications on regional carbon cycle, and develop a community renewable energy fund with the money that institutions save after switching from fuel oil to biomass. A biomass energy purchasing cooperative might serve to provide *some* of Middlebury's significant demand in the future.

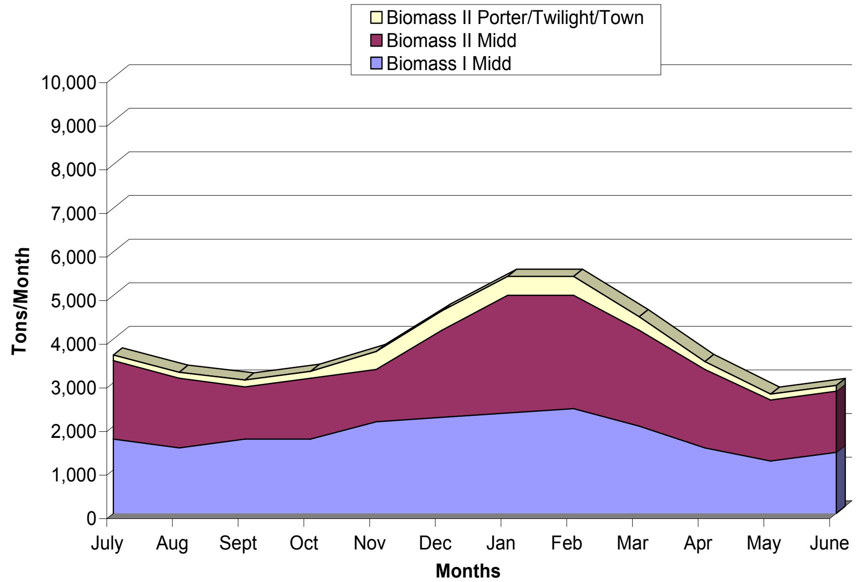

Figure 13: Current Middlebury plant production (Biomass I Midd) and possible production rates for future partnership plants (Biomass II Midd, Biomass II Porter/Twilight/Town)

Hybrid Partnerships

We could continue relying on a broker such as Cousineau for a portion of our supply, while simultaneously promoting alternative models for the remaining portion. This would allow for flexibility in pursuing the aforementioned alternative supply options, and give us the opportunity to directly support local loggers and landowners through pilot projects on the College's land and a local aggregation center.

In one pilot program, a local, trusted logger would harvest a proportion of the College's biomass on a plot of College-owned land, such as the Breadloaf forest. We cite Larry Altman as an example, since he is a trusted logger currently working in Ripton and has worked with Vermont Family Forests, adhering closely to VFF standards. Larry also has cut-to-length harvesting and log forwarding equipment that help minimize negative impacts to forest sites. This would allow us to make better use of the College's forested land for biomass procurement. Through this pilot project, we could both monitor the logging site, and assess the real cost of procuring woodchips harvested with strict adherence to our standards. [134]

An additional portion of our supply could come from College-run, or mill-partnership aggregation centers for small, private landowners. In the College run model (see aggregation station section), a College-built aggregation station would accept logs and chips from small landowners in a purchase upon delivery. The College could then contract a chipper and truck for further processing and delivery when supply and demand warrant. Alternatively, the College could partner with an existing mill (e.g., Jim Lathrop or A. Johnson) that already has the infrastructure and capacity to perform similar roles, which would simplify the process from the College's perspective, and be more socioeconomically responsible by promoting local businesses. While this scenario would

simplify the supply chain, give the College more direct control over its biomass procurement, and promote local economies, there are numerous challenges to its realization. In comparison to the College's current contract with Cousineau, reliability of the biomass supply is reduced. Cousineau has a greater operating capacity that allows more efficient coordination through diversification and optimization of costs according to variables such as fuel price. Secondly, the College would have to commit to taking roles such as logistical coordination that the specialized supplier is now managing under its own control and operation. Thirdly, selectivity of the sources and assuring compliance with the College's principles regarding sustainability again bring up issues currently under consideration for biomass supply from the broker. Acceptance of biomass upon delivery to the aggregation site must be made exclusive to suppliers that fulfill a certain set of criteria (e.g., proximity, land management standards), but how compliance with the criteria is monitored must be determined. Negotiation with the College's "receiver" will parallel those with Cousineau, and the College is likely to have to take on a larger role than it currently has in its biomass procurement.

To balance the benefits and drawbacks of each of these options, a hybrid program incorporating a contract with a broker, a pilot program on the College's forested land, a local aggregation station, and, in the future, incorporation of willows and stump dumps would be ideal.

Reducing our Demand

The most effective way of solving our fuel challenges is to significantly reduce our fuel demand. Decreasing the amount of #6 heating oil and increasing the proportion of our heat coming from biomass required to maintain the campus would not only lower our carbon footprint and the amount of oil and eventually woodchips we use, but also be economically beneficial and provide valuable educational opportunities for students, faculty and staff.

Based on a 2007 energy efficiency evaluation, numerous opportunities exist for Middlebury to significantly reduce the amount of energy and fuel needed to maintain campus buildings at current use levels. Fifty-three percent of the campus (928,000 square feet) are at least 50% below the standards for buildings outlined in Vermont Consolidated Act 250 and received a "poor" envelope rating. Act 250 is a set of guidelines for commercial and industrial buildings to establish base efficiency standards and performance requirements that are cost effective on a life-cycle basis. [135] While most of these College buildings have received basic energy-efficiency upgrades like attic insulation and storm windows, there is still opportunity for significant improvements both through easily applied smaller upgrades and through more considerable and expensive measures that should be incorporated into building renovations and routine maintenance.[136]

There are many ways to increase the energy and thermal efficiency of campus buildings. The optimal time for implementing large-scale improvements is during regularly scheduled building renovations. While the cycling of buildings offline for general maintenance and upgrades has been placed on hold due to current financial limitations, it is imperative that the upgrades not be delayed too long. For example, Forest Hall would be ideal to upgrade as soon as possible and incorporate energy

efficiency efforts into the renovation. Based on a report by Johnson Controls (Table 14), increasing roof insulation to R-30 and adding R-10 insulation to the interior of stone walls would result in respective annual savings of $2,731 and $10,999 annually, and reduce energy consumption by 5% and 31%. Replacing existing single pane windows with a dual pane low E glass would reduce costs by $3,122 and energy by 11% annually. These efforts combined would save the College $16,852 per year and reduce the buildings' energy use by almost half (47%).[137] Assuming these measures primarily reduce consumption of #6 fuel oil, Forest Hall would be responsible for a reduction of 155 tons of carbon each year and maintain the same level of comfort and use. The costs and logistics of cycling Forest Hall offline for a period of time in order to install these upgrades should be looked into as the long term benefits and economic returns likely outweigh the initial costs. This was the case in the upgrades incorporated into the McCullough and Proctor Hall renovations where 135,061kWh of energy, equivalent to approximately 76,000 lbs CO2 and $32,775, is now being saved annually as a result.[138] Therefore, it is important that the College does not delay too long in implementing the next scheduled upgrades on Munroe, Forest and Battell halls.[139]

Measure	**Yearly Energy Reductions (%)**	**Annual Savings (USD)**
R-30 Insulation	5	2,731
R-10 Insulation	31	10,999
Dual pane low E glass	11	3,122
Total Effects	**47**	**16,852**

Table 14: Effects of energy efficiency measures on Forest Hall.

Other upgrades that do not require the complete cycling of a building offline should also be examined. Timothy Perrin of Efficiency Vermont discussed ideal projects for 2010, which include: improving the HVAC systems in the Center for the Arts; reviewing compressed air systems in the Service Building and heating plants; applying drive controls to auxiliary pumps in the oil heating plant; using "virtual" rather than manual hardware in IT systems; and upgrading lighting and heating control options in campus buildings.[140] There are many more low to medium investment with high return ideas outlined in the 2007 Energy Audit.[141] Repairing and replacing steam traps to minimize steam leakage and increase the life of the system would require less than $1 per square foot investment and be paid back in five years or less. Installing variable speed drives and improving facility controls by upgrading to more direct digital control systems would each require investments of approximately $1 per square foot and be paid back in less than ten years, and significantly increase both the user and system efficiency and decrease the amount of heat required by allowing for more control and adaptation to times of day and temperatures in heated buildings.

Improving behavior and reducing the amount of wasted heat and energy would substantially decrease our carbon footprint. Beyond the overall building level, a lot of heat is wasted by campus users who cannot control the heat settings in their local area or room. For example, if a room is heated to 70^{o}F on a 20^{o}F winter day, up to 180 lbs of CO2 are wasted by heat exchange through an open window.[142] This is evident by students who must open their windows in the winter because they cannot lower the temperature of their room any other way. Installing individual controls or thermostats and

educating users on how to manage them would eliminate this problem. For example, Bowdoin has taken the initiative to install individual thermostats in each dormitory room or suite. Though the cost of adding thermostats is not known, they have seen significant improvements in both heating efficiency and comfortable temperatures, which reduces their carbon footprint. Additionally, making sure all doors of campus buildings have effective weather-strips would significantly improve energy performance and cost approximately $600 per opening with a less than 5 year return on that investment. Similarly, installing automatic shade controls and insulating shades would considerably reduce night time heat loss while permitting daytime solar gain, and have a 5-15 year return on an investment of approximately $200 per opening.[143] Based on the successful outcomes of 2009 upgrades, these projects and many others will likely have quick returns and significantly reduce our energy demand. The exact amount of carbon emissions avoided by these measures will depend on the extent and scale of the efforts.

On a larger scale, the College could lower the thermostat in all campus buildings by one degree. Assuming the temperature of all buildings heated by the College's central plant were dropped by one degree Fahrenheit, the College would save about 229,000lbs of carbon dioxide and more than $13,900 in fuel (#6 oil at $1.50/gal).[144] This is based on the two degree drop in temperatures (from 70^{o} to 68^{o}) campus wide in 2007. Another option would be to use energy efficient buildings such as Bicentennial Hall, Hillcrest and Axinn more, and inefficient buildings such as Munroe and Forest less. This would involve preferentially scheduling events in these buildings, and making sure that thermostats are lowered and lights are turned off when buildings are not in use.

The biomass plant provides a new opportunity for educating the campus community about energy use since our fuel now comes from our local environment and we can see the immediate landscape effects of our energy use. A tour of the biomass plant should be incorporated into first year student, faculty and staff orientation, with a corresponding visit to local logging operations and the willow plantations. Visual sculpture installations showing the amount of chips, or trees, it takes to heat the campus and photography exhibits showing the stories of the landscape and people who provide our chips could provide perspective to our heating demands. For example, many creative visuals including mounds of chips or rows of trees in prominent places could educate students that during the heating season (November to March) we need 36,000,000 pounds of chips to heat the campus, which is 238,410 pounds (or 50 cords) of chips per day. At VFF's calculations of 0.3 cords per acre per year, that means consuming the annual growth of 150 forest acres per day or 54,750 forest acres per year.[145] Assuming an efficiency of the entire system to convert chips to usable heat in a dorm of about 70%, we consume 38 pounds of chips per day to heat a 225 square foot room in the winter.[146] To raise consciousness, we could fill a showroom with the amount of chips required to heat it and invite students, faculty and staff to view the exhibit. In formal classroom settings, the biomass plant and sourcing could be a valuable educational tool for disciplines ranging from biology, geology, physics, political science, economics, to anthropology. Increasing campus consciousness about the biomass plant would inspire people to be more efficient about their heat and energy consumption, thereby lowering our demand for #6 oil and increasing the use of biomass not only as an energy supply but an educational resource. In this sense, the educational and social returns of the biomass plant could be significant.

VIII. Conclusion

It is clear that the creation of biomass procurement standards is a necessary and time sensitive improvement. The biomass gasification plant is a major commitment to sustainable management of an academic institution. It has rightfully garnered respect for Middlebury. However, it is important for both sustainability and publicity reasons to assure sustainable practices in all elements of its operation. There has been an understanding since the plant's inception that sourcing standards are an integral element of this progress.

To most comprehensively achieve the goals of the project we propose the following recommendations:

1) Identify where the College's biomass is coming from and how it is harvested.
2) Adopt and monitor proposed ES 401 standards.
3) Develop better carbon accounting and carbon transparency.
4) Explore potential alternatives to the current supply.
5) Continue efforts to reduce energy demand on campus.

As discussed, information on current biomass harvesting is the essential first step towards improvement. Without this information there is no way to impose standards on procurement. Once this information is available, the College will have to work closely with Cousineau to develop a contract that includes explicit adherence to standards. This will include provisions to work within a defined monitoring scheme. This would most likely take the form of a third party forester doing part time monitoring in collaboration with a student position. This operation assures some progress towards compliance and creates the educational benefits that are essential to social sustainability goals.

Additionally, the auxiliary sources of biomass should receive future consideration. The willow plantation presents a unique opportunity to have complete control over a substantial portion of our biomass plant. However, results from this test phase will determine the scale of possible application. Likewise, other alternatives (aggregation stations, etc.) will need to be assessed with the knowledge that these proposals put a large economic burden on the College. Any program that adds additional costs will be met with trepidation by the College.

Finally further exploration into carbon accounting is necessary. The College has defined the issue in a specific, simple way that overlooks certain elements of the heating process. Exact analysis of carbon emitted during each step of the supply chain – harvesting, chipping and transporting – in additional to the carbon emitted during combustion needs to be assessed. This needs to be compared against the amount of carbon sequestered by local forests to determine net carbon emissions in order to substantiate the College's claim of carbon neutrality.

Middlebury College has made a laudable commitment to the sustainable heating of the campus by investing in biomass fuel. The adoption and implementation of the recommended procurement standards will grant tremendous credibility to Middlebury's carbon neutrality goals. By taking into account our comprehensive evaluation of each step of responsible biomass procurement, the College can strengthen its position as a leader in environmental initiatives. Most importantly, putting our recommendations into action will benefit the College, the local community as well as the local and global environment.

IX. Appendix A

Middlebury College Biomass Monitoring Checklist

Site Harvester Name: ____

Landowner(s) Name: ____

Inspector(s) Name: ____

Date of Inspection: ________________________

Site Acreage: __________________

Site Location: ____

Status: Pre-harvest _______ During Harvest _______ Post-Harvest ________

MONITORING GUIDELINES:

Monitor will evaluate site on all 14 criteria as well as in accordance with the Vermont Water Quality Acceptable Management Practices (AMPs). Each criteria will be given a rank based on the 1-5 scale outlined below, where 1 is the lowest level of compliance and 5 is the highest.

(1) A score of 1 should be given when compliance is essentially non-existent or is very poor.

(2) A score of 2 should be given when compliance is present but is minimal and unsatisfactory.

(3) A score of 3 should be given when compliance is average.

(4) A score of 4 should be given when compliance is satisfactory but still somewhat below standard.

(5) A score of 5 should be given when there is full compliance with the standard.

SUSTAINABLE FORESTRY:

1	2	3	4	5	
___	___	___	___	___	Tree tops and all material less than 4 inches in diameter left at the logging site.
___	___	___	___	___	At least 2 down trees or logs retained per acre exceeding 14 inches in diameter on average.
___	___	___	___	___	Residual stand damage confined to 10% or fewer of the dominant or co-dominant trees.
___	___	___	___	___	Clear-cutting avoided; canopy openings are generally less than 0.25 acres and no larger than 1.25 acres.
___	___	___	___	___	Appropriate drainage control measures, such as water bars, should be installed on skid trails to protect water quality. (*See Table at end of checklist*)
___	___	___	___	___	All bodies of water kept free from logging debris and waste.
___	___	___	___	___	Stream crossings are at right angles to the stream channel.
___	___	___	___	___	Truck roads are built at grades from 3%-10%.
___	___	___	___	___	Skid Trails are built at grades from 3%-15%.

WILDLIFE PROTECTION:

1	2	3	4	5	
___	___	___	___	___	Steps taken to preserve Indiana bat habitat in areas conducive to their habitation.
___	___	___	___	___	100-foot buffers of original vegetation preserved between wetland, stream, pond or lake and active cutting areas. On steep slopes, buffer strip extended to 150 feet.

AESTHETICS AND RECREATION STANDARDS:

1	2	3	4	5	
___	___	___	___	___	Signs notifying recreational users of the harvesting operation and safety concerns are displayed.
___	___	___	___	___	Buffers of at least 150 feet between landing areas and any major roads and buffers of at least 100 feet to hiking and recreation trails maintained for aesthetic value.
___	___	___	___	___	Crossing of hiking trails when creating skid tracts is minimal; trails only crossed at right angles.

TOTAL POINTS: __________

PERCENT COMPLIANCE (total points/70): __________%

<u>Recommended Distances Between Drainage Structures on Logging Roads</u>

Road Grade (percent)	Distance Between Waterbars (ft)	Distance Between Culverts (ft)	Distance Between Turnups, Dips & Pole Culverts (ft)
1	400	450	500
2	250	300	300
5	135	200	180
10	80	140	140
15	60	130	130
20	45	120	120
25	40	65	- -
30	35	60	- -
40	30	50	- -

Notes

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